A WINDOW OPEN ON THE WORLD

The UNESCO Courier

JULY-AUGUST 1964 (17TH YEAR) - PRICE 2/-STG. (U.K.) - 60 CENTS (CANADA) - 1.40 F (FRANCE)

WATER AND LIFE

U.S. Bureau of Reclamation

GREAT DIVIDE

For millions of years surging river waters have gouged out mighty ravines in the crust of the earth. The energy that once flowed away to the sea is now serving economic development (see page 32). Above, construction work on the Glen Canyon Dam (now completed) across the Colorado River (U. S. A.) whose water will irrigate 560,000 acres of farmland.

The UNESCO Courier

JULY-AUGUST 1964
17TH YEAR

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Water and Life

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COVER PHOTO

During seemingly endless weeks and months land and peoples of South Asia have sweltered under the searing heat. Now, as the monsoon brings relief a young Indian women joyfully raises her face to greet the first drops of rain (see photo story on page 42).

© Magnum - Brian Brake

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UNESCO ARCHIVES

The great waterfall of the Iguassu River, on the frontier between Brazil and Argentine (237 feet high and one and a half miles wide) is even mightier than Niagara Falls. Every second more than 61,660 cubic feet of water pour over the Iguassu Falls —enough to supply the need (per second) of a community of 80 million people. The River Iguassu rises in eastern Brazil and runs for 380 miles before joining the Parana River on which there are the even larger Guayra Falls which have the biggest outflow of water in the world.

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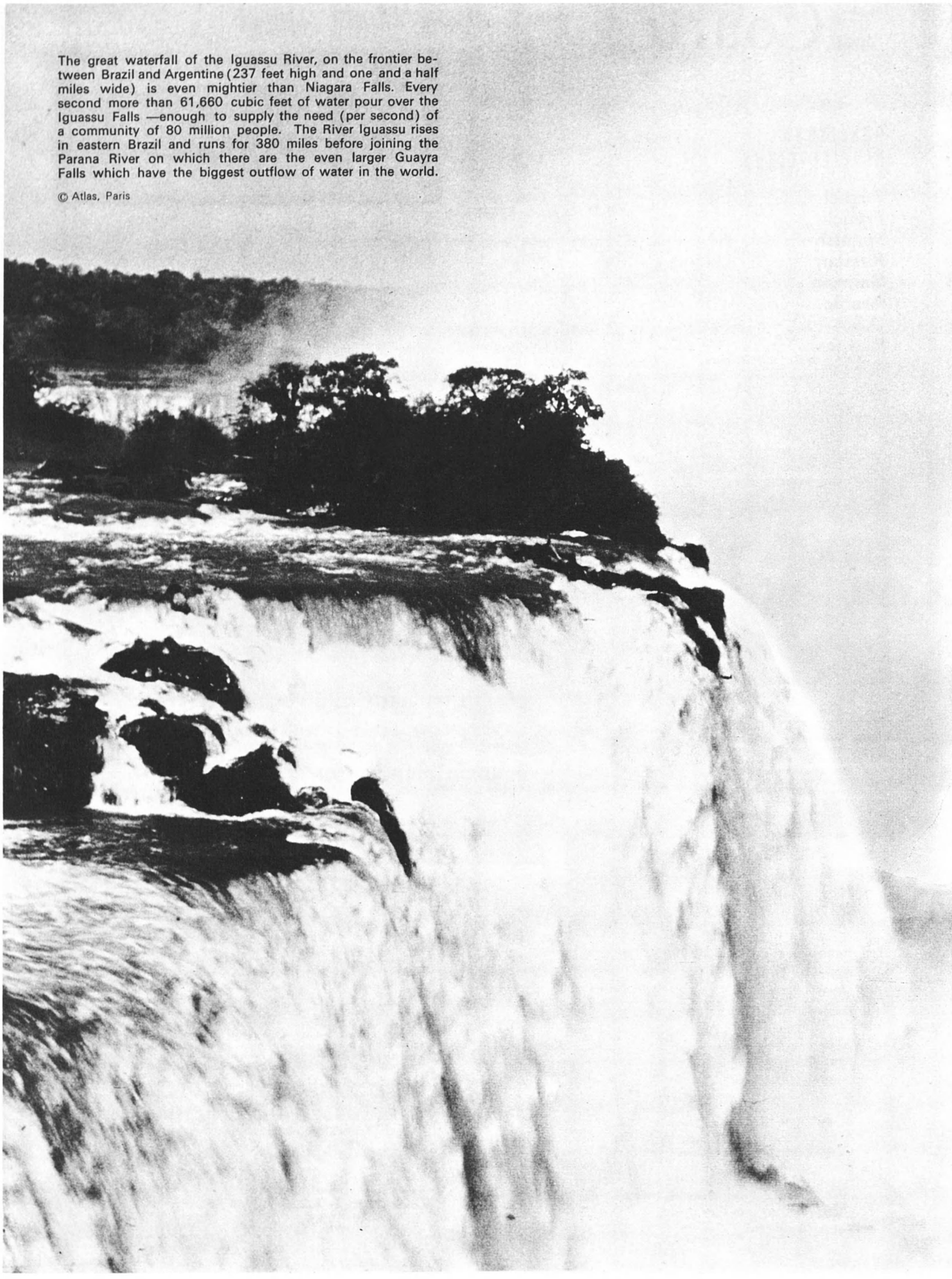


The International Hydrological Decade

A WORLD-WIDE PROGRAMME OF SCIENTIFIC RESEARCH

by Michel Batisse

OUR need for water is constantly increasing, whether we are turning a tap in our own home, irrigating our fields or running the cooling equipment in our nation's electric power stations and industries.

There is an automatic increase due to population growth. Because of this increase alone, in 20 years time we are likely to be needing more than three cubic metres of water where two suffice today. The overall improvement of living standards to which all men aspire, the fight against hunger through the irrigation of more land for food growing, the creation and expansion of new industries all foretell the need for even greater water supplies throughout the world. Though it is difficult to calculate the exact amount, it is safe to say that in 20 years' time the demand for water will roughly double.

Such a rapid increase in water consumption can only be met through water-works programmes of tremendous scope and diversity. In many places we shall be obliged to turn to increasingly remote and inaccessible sources for our water, or obtain it through the costly processes which purify polluted water for further use or remove the salt from sea-water.

In any case, whether we are concerned with transporting water over great distances, storing it in reservoirs or maintaining its quality, the installation and construction work involved in doubling our water supply within the next two decades will cost a fabulous amount—possibly several millions of millions of dollars for the world as a whole.

Faced with such a situation it is obvious that we should search as widely as possible and with every available means for those sources of fresh water that seem to be the least costly. But where do these sources exist? Only a sustained and co-ordinated programme of scientific observation and research in hydrology will tell us the answer. This is the purpose of the International Hydrolological Decade.

The water resources in a region, or a country or even for the whole world

CONT'D ON NEXT PAGE

can only be estimated through quantitative studies of the water "balance sheet" of the river basins. As with any balance sheet, we first have to add up the entries on the "credit" side, that is, the quantities of water that are received in the form of rain or snow. Then we have to total up the "debit" side: what happens to this rain, how much of it runs off to the rivers, how much seeps underground, how much evaporates into the atmosphere, how much is absorbed by plant life and then discharged into the atmosphere by the process of transpiration. Other studies relating to changes in the quality of water or the impact of man's actions on the hydrologic cycle are also needed.

All this work and all these aspects of research are the domain of hydrology—the science of the world's waters, the different forms in which they exist, their circulation and distribution over the globe, their physical and chemical properties, their interactions with the environment, including their responses to human activity.

As everyone realizes, there is always a period between the discovery of scientific facts and their practical application. In hydrology, however, we still know too little about many aspects of the subject to be able to produce rational solutions to water supply problems that will be facing us tomorrow. There are plenty of examples to support this view.

The chief problem for the hydrologist, for instance, is that he has to deal with a most unreliable element. During certain months or years, the river levels are low and wells run dry. Agriculture and hydro-electric production are hampered by shortages of water. Conversely, some periods are too wet and disastrous floods are unleashed.

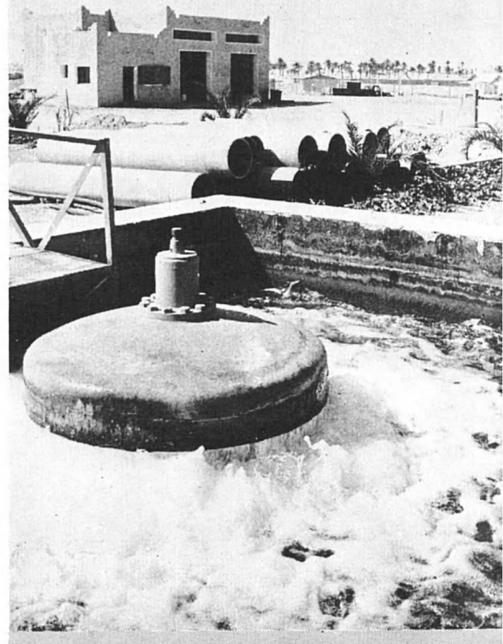
If hydrology is really a science, it should enable us to forecast the behaviour of the natural phenomena with which it deals. The hydrologist should be able to tell the dam builder what the maximum flood level is likely to be over the next 100 years. He should be able to forecast how much water will be available during a dry summer. Unfortunately, in the field of hydrological forecasting we have still no reliable means of finding out these things, since we lack records of observations carried out over a sufficiently long period, and because we still know too little about the laws governing fluctuations in climate and the movement of water.

UNDERGROUND water reserves are much larger than those on the surfaee, but as they are unseen we tend to underestimate them. It is vitally important that we make use of these underground reserves, but never blindly or haphazardly. For example, where does the water come from which we find in one or another of the underground water bearing layers (the "aquifers")? How does it move? How is it renewed? The age of an underground aquifer—the time the water has been there—may vary from a few weeks to several thousand years. The aquifer may even be completely "fossile" and never be renewed at all. And if this water is used, what effect will it have on the discharge and future level of the water table? What are the laws of hydrogeology? Despite the immense progress of recent years, all these questions have still not been fully answered.

Water storage in a natural reservoir under the earth, free from evaporation and sedimentation which plague surface dams, the pumping of these sources and even replenishing them should their supply become exhausted—all these offer the engineer a vast field full of remarkable possibilities. But here too his action must be based on accurate knowledge of the phenomena he is using or creating, and so far we are only just beginning to glimpse this knowledge.

A similar need for scientific research exists in the branch of hydrology that deals with the quality of water. In nature there is no water like the pure water defined by chemists, made up only of hydrogen and oxygen. River water, ground-water and even rainwater always contain other dissolved or suspended elements, and these, even when present in small quantities, play an important role. In the case of irrigation farming, for instance, every drop of water brings with it a little salt: the water evaporates but the salt remains and gradually poisons the soil and plants. In general we now know how to remedy this problem of salinity with the help of leaching and drainage. But many ques-

A GROWING PROBLEM...



Water bubbles and foams as it reaches the surface through an artesian well drilled deep under the desert at Ouarga in the Sahara. The hidden water is reached at widely varying depths: 240 feet at El Golea, 3,280 feet at Ouargia and nearly 5,000 feet at Touggourt. The reserve of water locked up in the immense artesian basin of the Sahara has been estimated at 16 million million cubic yards.

© J.-D. Lajoux

Every day the city of New York uses up over 1,000 million gallons of water. These supplies are checked weekly for purity, and beach and harbour water is watched constantly. Here an engineer of New York's health department takes samples in the harbour.

USIS

Thanks to irrigation in the south of the Sudan, some 250,000 acres of parched land have been reclaimed for crop-growing. But here, as in other parts of the world, the effects of irrigation on the quality of the soil and on underground water reserves has created still unsolved problems.

© Paul Almasy, Paris

tions remain unanswered regarding the effect of irrigation and drainage on the quality of ground-water and the possibility of maintaining the ground-water level below the zone of plant roots while bringing to the surface the water necessary for irrigation.

What happens exactly in this thin layer of soil which preserves the moisture necessary to plant life? What form, liquid or vapour, does the water take in this zone? What forces act on the water, depending on the kind of soil present? How long will this life-giving moisture last? Evaporation from the soil and transpiration of vegetation are responsible for the direct return to the atmosphere of more than half of the water which falls on the land.

How exactly do these phenomena, which represent an enormous loss of resources, occur? What part does a forest play in the water balance-sheet of a given area? Does it act merely as a water-consuming mechanism operating through the absorption and transpiration of trees, thereby reducing the quantity of runoff which reaches the rivers or, on the contrary, does it result in a slow seepage into the earth which can later be recovered in the form of ground-water, while at the same time avoiding erosion? These are the kinds of problems which have still to be resolved in relation to all known yardsticks and all the different cases which arise in nature; the answers will only be found through a vast programme of scientific research.

...IN EVERY COUNTRY

SCIENCE has never progressed in isolation. To increase international contacts between hydrologists is already an effective way of promoting hydrology, just as international co-operation among physicists helps to promote physics.

However, in the case of hydrology the subject itself has an international character. Rivers and ground-water reserves know no frontiers. No country, however large, can hope to have within its borders all the possible kinds of hydrological situations which must be studied and compared so that basic conclusions can be drawn. The presence and distribution of water on a continent or in any area of the globe is the result of water circulation on the earth as a whole; in other words, hydrology's laboratory is the world at large.

There are still other reasons to justify an international programme. Every country, whether economically developed or not, is facing problems created by the rapid development of hydraulic resources. But everywhere there is a shortage of top specialists and technicians in hydrology. While more have to be trained the best use must be made of those we already have, in order to help the many countries which are still inadequately equipped in this field. Finally, more students must be encouraged to take up hydrology; public and official interest in water problems must be aroused, before even more difficult situations arise; and every appropriate scientific resource should be put at the service of hydrology. We shall only achieve these goals by creating a strong force of public opinion, which will only make its full impact if internationally based.

The variability of hydrological phenomena from year to year mitigates against the concentration on an international programme over a short period —during one year for instance—as has been the case in other fields of science. This is why the idea of a decade was proposed. From the hydrologist's viewpoint a 10-year study is not a very long one. Hydrologists prefer wherever possible to work from observations made over much longer periods. But a decade should give time for many scientific investigations and enable the goals which have been set at the international level to be reached.

The general programme of the International Hydrological Decade was worked out by an intergovernmental meeting of specialists held at UNESCO'S headquarters last April. It is a vast programme, embracing all aspects of hydrology. The meeting also singled out plans for action during the first part of the Decade, which is due to begin early next year. These plans

CONT'D ON NEXT PAGE

A unique stocktaking of our resources

are based on the contributions for the general programme proposed by nearly 60 nations.

An initial group of activities covers the collection of basic data. Thanks to the Decade, observation of hydrological events—the quantities of rain and snow that fall, the discharge of rivers and underground sources, the amount of sediment that is moved, etc—should be given a major boost, especially in the developing countries.

Basic data of this kind are not only the raw material of hydrological research; in many cases they will be of practical use to engineers for the simple reason that if in 20 years time water works are to be constructed on a river about which little is known at present, now is the time to start making hydrological observations.

Comparisons can only the made at the international level and a general pattern of rules deduced on the basis of uniform and reliable measurements. This is why hydrological stations in each country will be designated as Decade Stations. In the well-equipped countries, this simply means that some existing stations will be chosen and given special tasks. But in other countries Decade Stations will have to be built, so as to create an international network that is sufficiently dense and representative.

A second group of activities will deal with inventories and water balance sheets, starting with those of the small basins and working up to the large rivers, to continents and even to a world scale level. Research of this kind assumes that sufficient basic data already exist to bring out a pattern which alone can give an overall picture of the basin concerned. For a better understanding of the hydrologic cycle as it operates in various natural, characteristic areas, corresponding for instance to different climates, many countries will set up "representative basins" which may cover a surface area of several hundred square kilometres. These areas will include at least one Decade Station, and comprehensive observation facilities. "Experimental basins," which will be smaller than the representative basins, will also be set up. Here, the natural conditions will be deliberately modified—the vegetation will be changed for instance—so that the effect of these modifications on the hydrologic cycle can be studied.

A final group of projects will investigate a broad range of problems involving scientific research in its strictest sense. Scientists will be looking for answers to the kind of problems that have already been mentioned. Every branch of hydrology—runoff, soil moisture, evaporation, movement of ground-water, the dynamics of lakes, estuaries and deltas, the evolution of glaciers or the geochemistry of water—raises a whole series of fascinating problems of immense theoretical and practical significance.

The International Hydrological Decade is planned as an international venture in scientific co-operation. It is up to individual countries to make whatever contribution they can to the programme. Since hydrology concerns many different sectors in every State, National Decade Committees are being set up to co-ordinate national activities. Some forty such committees have already been formed. To provide overall direction at the international level, it is planned to set up, during UNESCO's General Conference in November, a Decade Co-ordinating Council comprising representatives from 18 countries.

UNESCO plans to make a major contribution towards the success of the Decade, by arranging for the exchange of scientific information, the organization of working groups and, in particular, the training of hydrologists in countries where they are most needed. Other U.N. organizations, above all,

Electric generating stations use enormous amounts of water. To overcome the problem of obtaining water on this scale, ways have been devised to make use of the same water again and again by pumping it through cooling towers, like the one shown below at Etiwanda, in California. The hot water evacuated from the generating plant is taken to the top of the tower. As it drops to the bottom it is broken into droplets by millions of wooden slats and crosspieces inside the tower and cooled by huge fans.

USIS

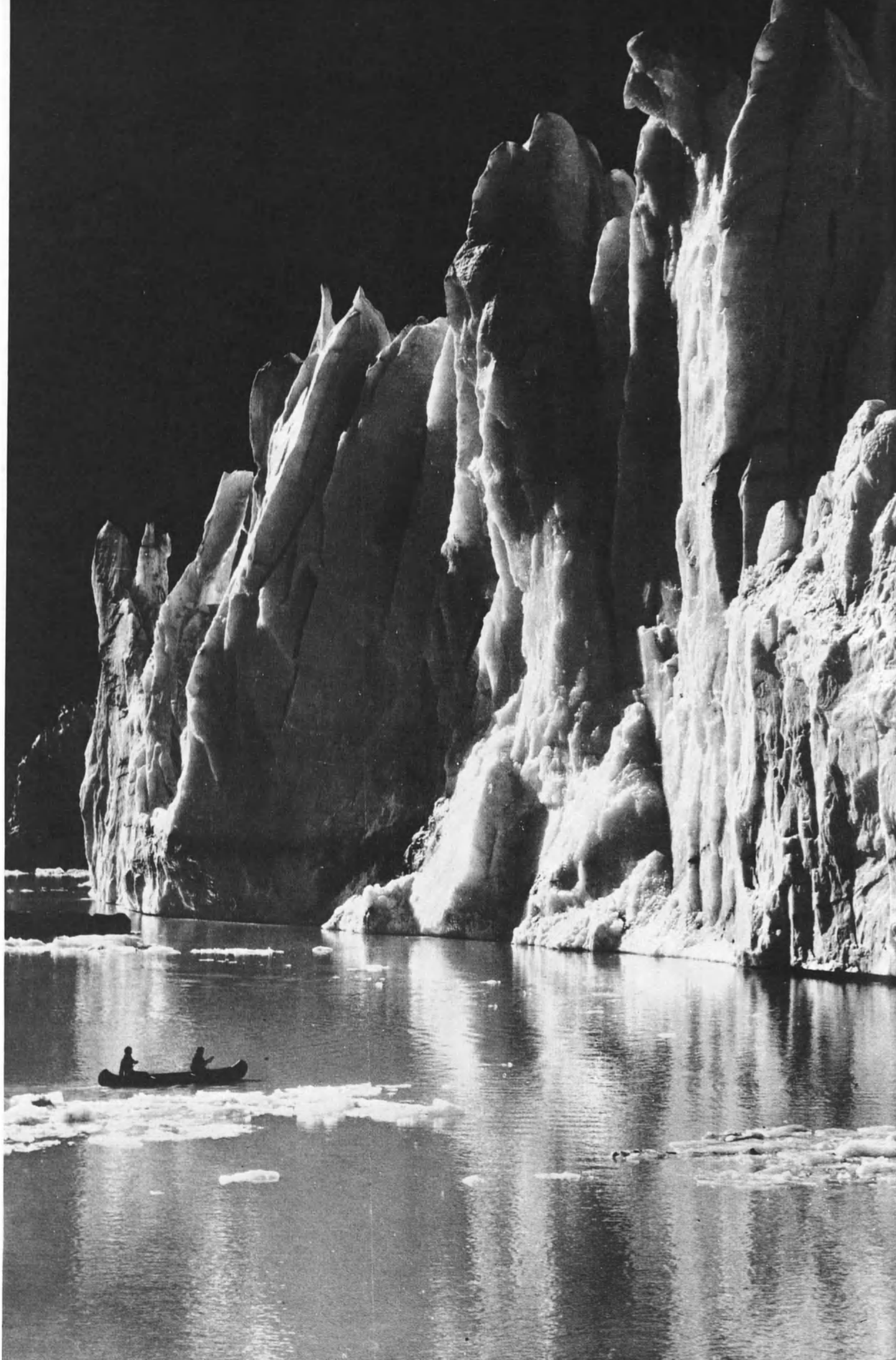
the World Meteorological Organization and the Food and Agriculture Organization are also preparing to contribute actively to the Decade. Finally, many international scientific organizations will also participate, especially the International Association of Scientific Hydrology which has worked for more than forty years for the advancement of this science.

The International Hydrological Decade is a unique co-operative scientific undertaking which will bring immense practical results. It will promote rapid development of hydrological knowledge and should provide reliable scientific foundations on which to base the complex and delicate decisions which governments must soon take if man is to obtain all the water he needs.

INDUSTRY NEEDS 220 GALLONS OF WATER TO PRODUCE:

440 to 880 lbs of coal
20 to 140 lbs of steel
15 to 45 lbs of paper
4 1/2 lbs of rayon

MICHEL BATISSE, *a French physicist and engineer, has been a member of Unesco's Department of Natural Sciences since* 1951. *A specialist in arid zone problems, he was appointed as co-ordinator of Unesco's Major Project on Arid Zones in* 1957. *Since* 1960 *he has been head of the Division for Research Relating to Natural Resources, which is launching the International Hydrological Decade.*



About 97 % of the world's water is in the oceans. Over two-thirds of the fresh water reserves are frozen up in glaciers and, above all, in the polar icecaps. If the Antarctic icecap melted it would produce enough water to feed all the world's rivers for about 800 years. The earth's land areas are dotted with hundreds of thousands of lakes which contain 100 times more fresh water than all the rivers and streams combined. This gigantic cliff of solid ice is a section of the Lituya glacier on the Pacific coast of Alaska.

© Bradford Washburn, Boston

WATER IN THE WORLD

by Luna B. Leopold

The earth, including its oceans and atmosphere, is a giant distillation system whose operation brings about the distribution of fresh water throughout the world, from the frozen wastes of polar regions to the burning equatorial deserts. Stated in the simplest terms, distillation, condensation and liquid flow are the elemental processes which, on a grand scale, distribute and circulate throughout the world the water which is essential for all life.

Water in liquid form absorbs heat energy, chiefly from the sun, and the absorbed energy changes the water from liquid to gaseous form. Transported in the atmosphere, the vapour later meets cooler conditions and condenses as precipitation, some of which replenishes the water in land areas.

Because water is continually being transformed from liquid to vapour and back to liquid again, the whole sequence of events ends where it began. That is, the condensed moisture in the form of precipitation runs into or off the surface of the earth, and a part of it collects in rivers which flow to the ocean. The events together form what is called the hydrological cycle.

The cycle cannot be stopped, fortunately, owing to the fact that the energy which streams constantly to the earth from the sun is inexhaustible. I say fortunately because, were this cycle to stop, there would no longer be that essential renewal of water as rain and snow to maintain rivers and soil moisture and to grow the plants and sustain animals on the continents. Indeed, were the cycle to be stopped for some cosmic reason, all water would finally come to rest in the oceans, and life could continue only in the marine realm.

Though man is not able to alter the global cycle materially, he may interrupt it locally by managing water to serve his needs. That part of the cycle from which man may take water contains but a small part of the world's total. Of the water which is precipitated as rain or snow in the land areas, somewhat more than two-thirds is returned to the atmosphere as water vapour through

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Antarctic ice = world's river flow for 800 years

evaporation and transpiration by plants. These processes, then, have first call on precipitated water and their demands must be met before any runoff can occur in rivers.

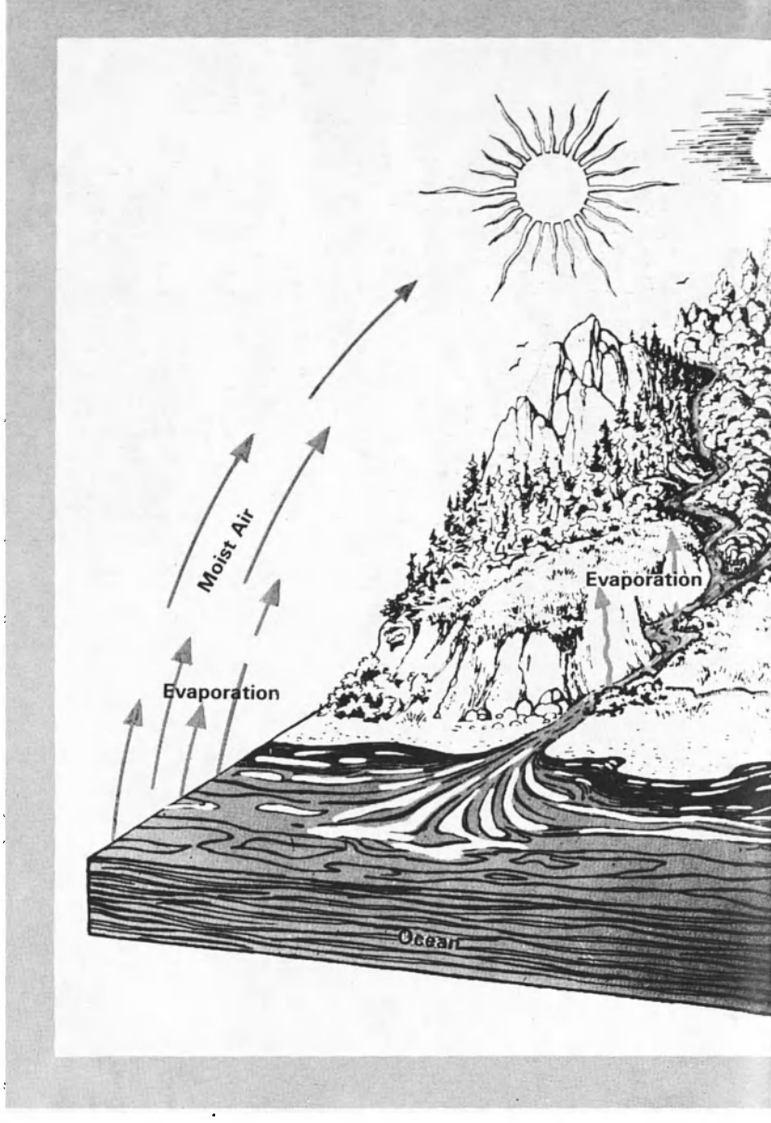
Considering how important is the water in rivers, lakes and ground-water reservoirs, it is surprising how little of the total water of the world is in forms and places from which man may draw it with relative ease to meet his needs. In the present state of technology and water economics, the amount of water which can be drawn from salty sources such as the ocean is insignificant compared with man's total need. Yet the reservoir of salty water constituting the oceans is by far the major portion of water on the earth. The oceans of the world contain 97% of all the water in the globe. The next largest item in the water budget is also essentially unusable by man: more than two per cent of the world's water frozen up in glaciers and icecaps (see chart below).

The amount of water in the icecaps is large compared with that in rivers. If the Antarctic icecap were melted, the amount of water freed would, if supplied at a uniform rate, feed the Mississippi River for 50,000 years. It could provide the flow of all the rivers in the world for about 800 years.

Rivers constitute for mankind as a whole the principal source of water. Yet, surprisingly enough, this principal source contains at any one moment only about one hundredth of one percent of the water on the globe.

Being such a small percentage, it is therefore understandable that the surface water varies in availability owing to the exigencies of day-to-day and month-to-month weather and the large differences in climatic character from place to place on the continents.

Because water is essential for man's existence, ways of providing him with what he needs have been discovered and rediscovered by successive generations and under a great variety of environmental conditions. Many civilizations and certainly many cultures have derived their particular stamp and character from the conditions of life within which local water supplies had to be derived. Man has shown great versatility in finding ways of making use of water as it occurred in its great circle through the hydrologic ring.



Modern water problems, in fact, seem to be merely variants of the age-old difficulties that mankind has faced again and again. The water problems in the modern world are largely problems in *learning to manage a variable resource.* This is exactly the problem faced by ancient civilizations when man first began to build small dams for the diversion of water in surface channels, when he learned to dig wells, and more recently when he developed the centrifugal pump and iron pipe.

Consider again the statement that the water most easily available to man is an extremely small part of the total water on the earth. The ease of withdrawal is of course influenced by the amounts from which withdrawal is to be made, and these amounts are highly variable. The resource would be much more variable than it actually is were it not for the effect of the porous soil which acts as a simple but universal natural regulating reservoir.

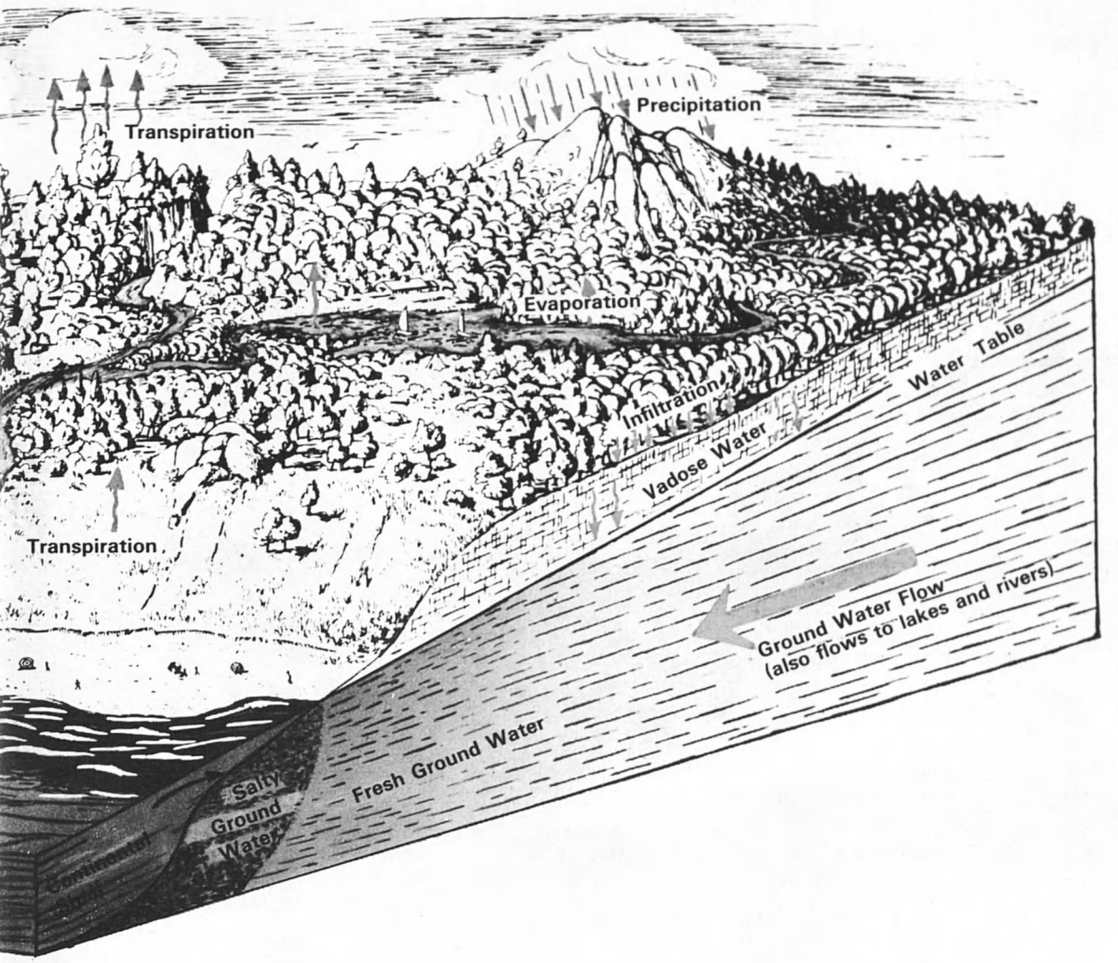
Storage of any commodity tends to even out the variations of supply and to provide a more uniform output. Winter storage of water is one way to reduce seasonal variations and to make the supply sufficiently uniform to last during periods of deficient rainfall. Storage, therefore, is the key both in the natural environment and in man's hydraulic works, to decrease the variability of the inflow. Outflow from a storage reservoir can be uniform even though inflow to the reservoir is very erratic.

Water flows in river channels even during long rainless periods because the precipitation from previous storms has been temporarily stored in the ground and is now being slowly released. Thus streamflow is less erratic than precipitation because of the storage provided by the porous earth.

WORLD'S ESTIMATED WATER SUPPLY

LOCATION	*Water volume (cubic miles)*	*% of total water*
Fresh water lakes.....	30 000	0,009
Saline lakes and inland seas.	25 000	0,008
Averege in rivers and streams	300	0,0001
Soil moisture and near-surface ground water	16 000	0,005
Ground water within depth of half a mile.....	1 000 000	0,31
Ground water-deep lying...	1 000 000	0,31
Total liquid water in land areas.....	2 070 000	0,635
Ice caps and glaciers.....	7 000 000	2,15
Atmospheric water	3 100	0,001
World oceans	317 000 000	97,2

(From Raymond L. Nace, United States Geological Survey)



THE WATER CYCLE

All water comes from the ocean and is returned to it in a continuous hydrological cycle. Subcycles, or short circuits, occur on land where water evaporates or is transpired by vegetation. The water vapour contained in the atmosphere amounts to less than a one hundred thousandth part of the waters of the globe. A single cabbage may withdraw and transpire one quart of water daily, and a quite ordinary tree as much as 50 gallons. The immense reserve of underground water (3,600 times the volume of the water flowing in all the world's rivers) in the first half mile of the earth's crust shares in this cycle of water movement by flowing into rivers, lakes and the sea.

Drawing © "Natural History", January 1964

But man still has much to learn about using the natural storage provided by nature. An example of how large is one part of this natural storage is the amount of water in the ground. Water stored naturally in the ground within the upper half mile of the earth's surface amounts to about a million cubic miles of water. This is some 3,000 times larger than the amount of water in the rivers of the world at any given moment in time. It is also 20 times larger than the amount of water in all the fresh water and saline lakes and inland seas in the world.

By far the largest amount of usable water at present not used by man is underground. Compared with this stored ground water, the amount which can be stored by dams on rivers is small indeed. The difficulty is that ground water, lying unseen, is not as easily surveyed or estimated, and usually requires considerable technical knowledge and modern equipment to exploit on a large scale.

Moreover, because ground water is a stored reserve, its exploitation may under certain circumstances lead to its exhaustion. Or exploitation may lead to lowering of the ground water levels to such a depth that further exploitation becomes too costly. This might be described as economic exhaustion.

One of the great needs, therefore, is to learn how to put water underground into the natural storage reservoirs provided by porous rocks and gravel, in large quantity and economically. If this were done, one could withdraw the water again by pumping during times of shortage and would avoid the losses by evaporation which may be important in surface reservoirs.

Furthermore, the storage space available underground in porous materials is nearly everywhere very much larger than the space even in the largest man-made surface reservoir. But we have not yet learned how to use the underground storage in the most practical ways.

In summary, there is much more water on the earth than man can use, but most of it is salty and relatively little is actually available for human use. The small amount available is variable in time and space and these variabilities are the cause of water problems.

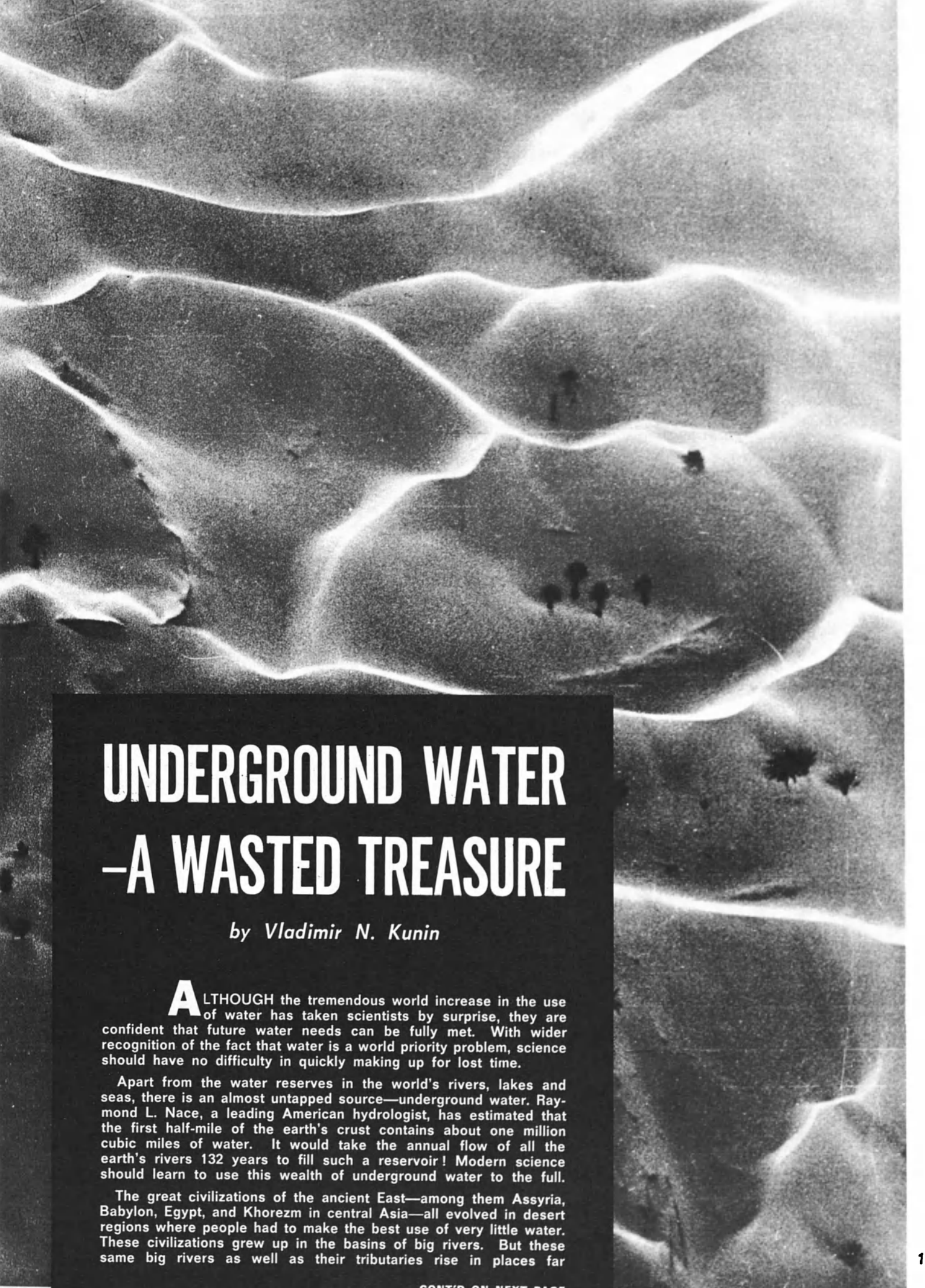
The principal approach to eliminating variability is storage and the natural storage provided by rocks and unconsolidated materials just beneath the earth's surface exceed by far the surface storage facilities man has built or could build even in the most advanced countries.

Advanced technologies allow withdrawal of ground water faster than it can be replenished by natural recharge. Overdraft on water in one place relative to another may worsen water problems by increasing the geographic variability of usable water, as is described in other articles in this issue of The Unesco Courier. The International Hydrological Decade is an attempt by Unesco to attract world attention to the importance of learning more about water on the earth. It is hoped that the results of such improved knowledge on the occurrence of water and the processes involved will improve man's ability generally to utilize this resource better and more efficiently for the good of mankind.

Luna B. Leopold *is chief hydrologist of the U.S. Geological Survey, Dept. of the Interior, Washington, for which he directs studies on river measurements, ground water and water quality. He has written many studies on hydrological problems and his most recent work, "Fluvial Processes in Geomorphology" was written in co-authorship with M.G. Wolman and John P. Miller.*

Even in the most arid deserts palm trees sometimes survive (as in this striking air view of the Sahara) by drawing nourishment from underground water. But there is always the threat that they may be buried by sand dunes displaced by desert winds.

© Emil Bronner, Braunwald, Switzerland



UNDERGROUND WATER —A WASTED TREASURE

by Vladimir N. Kunin

ALTHOUGH the tremendous world increase in the use of water has taken scientists by surprise, they are confident that future water needs can be fully met. With wider recognition of the fact that water is a world priority problem, science should have no difficulty in quickly making up for lost time.

Apart from the water reserves in the world's rivers, lakes and seas, there is an almost untapped source—underground water. Raymond L. Nace, a leading American hydrologist, has estimated that the first half-mile of the earth's crust contains about one million cubic miles of water. It would take the annual flow of all the earth's rivers 132 years to fill such a reservoir! Modern science should learn to use this wealth of underground water to the full.

The great civilizations of the ancient East—among them Assyria, Babylon, Egypt, and Khorezm in central Asia—all evolved in desert regions where people had to make the best use of very little water. These civilizations grew up in the basins of big rivers. But these same big rivers as well as their tributaries rise in places far

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Tools of today's water detective: radio and aerial photography

removed from the deserts; they are "strangers" to the places where they bring the greatest benefit. By using local water man has also farmed desert and semi-arid areas in places far beyond the areas watered by these "stranger" rivers. I am sure that if a proper study were made of all the traditional methods employed by the desert peoples to obtain and make use of water, and if modern science and engineering were applied to perfect these methods, many water supply difficulties would be overcome. This would give temporary relief until such times as cheap ways of pumping underground water and of demineralizing and purifying surface waters (and of using them several times over) are introduced.

The underground waters in some of the Transcaspian deserts for instance are all highly mineralized; yet from far-off times man has successfully bred livestock in these deserts. He solved his problem in two ways: by artificially creating fresh subsoil water and by giving cattle and sheep saline water to drink.

Fresh subsoil water formed by the infiltration of rain from the catchment basin has been utilized since ancient days. At the end of the nineteenth century engineers began to use a method of regulating water resources by the artificial replenishment of subsoil waters. Desert peoples, however, had actually been using similar methods for centuries.

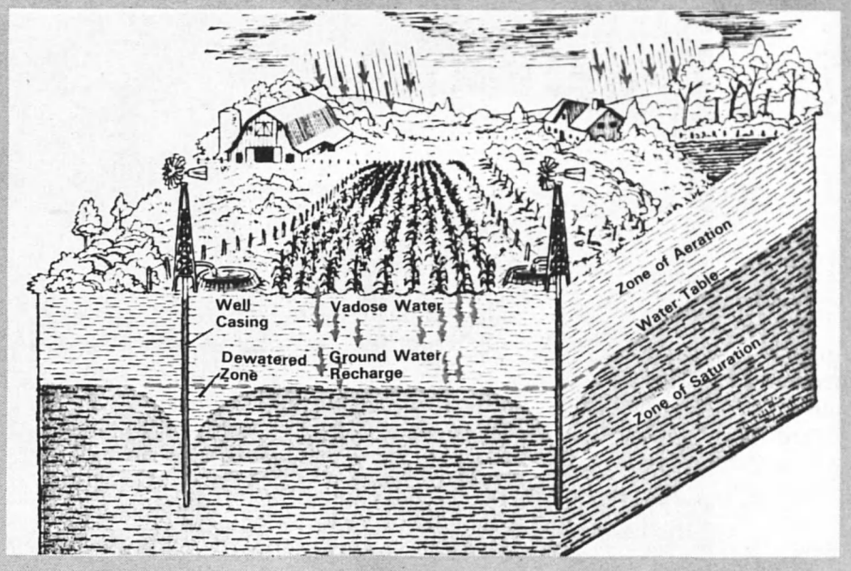
Such techniques, of course, are only practicable when there are sufficient rains, an extensive catchment basin, a high run-off from the surface and suitable geological conditions for the accumulation of subsoil waters. An annual rainfall of 80 mm., of which half should be concentrated in two or three months, has been found sufficient.

Even in a desert with clayish soil the run-off only accounts for between 1/10th and 1/5th of the of the total rainfall. However, the use of synthetic substances to form artificial drainage areas should produce a higher rate of run-off. Other methods to assist

'PIPELINES' FROM THE PAST

Long lines of giant "mole hills" running cross the countryside in Iran (below) mark the route of underground galleries called "kanats" (also spelt "qanat" and "ghanat"). Pockets of water that collect underground at the foot of the mountains are tapped and flow along these tunnels, sometimes for many miles, to crop-growing areas. The "mole hills" mark the site of vertical shafts through which earth was excavated during tunnelling operations, and which now provide ventilation. Kanats were first developed in Iran some 3,000 years ago and their immense network made possible the economic prosperity on which the power of the Persian Empires of antiquity was founded. Without the kanats, cities like Teheran, Tabriz and Chiraz would probably never have existed. Today more than 30,000 kanats are still used in Iran, mostly for irrigation.

Michel Batisse



Beneath most land areas of the world there is a zone where the pores of rocks and sediments are completely saturated with water. Hydrologists call this "ground water", and the upper limit of the saturated zone is called the "water table". They are now studying how to detect and make use of the deep layers of water and also how to avoid exhausting them.

Drawing © "Natural History", January 1964

LEGENDS OF THE SPRINGS

The peoples of the ancient world saw no particular relationship between rain or storms and the underground water in wells and hill-side springs. "The waters of the ocean penetrate deep into the earth under wind-pressure and rise to feed the springs thanks to gravity, which compresses the rocks", said the Greek philosopher and astronomer, Thales of Miletus, in the 7th century B.C. Plato also thought that water reaching the surface came originally from the ocean, through a deep abyss descending to the centre of the earth. "My observations", said Seneca, "show that rainfall cannot explain the formation of springs, for it can penetrate only a little way into the ground whereas it is evident that springs sometimes originate at great depths... rain is never sufficiently strong or continuous to sink more than ten feet into the ground." It was only in the 16th century that science began to offer explanations more akin to present-day views.

the replenishment of subsoil waters will also have to be used until anti-evaporation substances that effectively retain fresh water have been devised. These substances will be most effective if used in small basins where there is no disturbance of the water.

Because rainwater provides only a minimum water supply the desert herdsmen have had to train their stock to drink salt water. Some valuable animals—camels and caracul sheep, for instance—drink water with a salt content of from 10 to 12 or even from 15 to 16 grammes per litre, gain weight regularly and breed normally. There is no reason why similar uses should not be made of such water in other areas.

RECENTLY much has been written about the use of heavily saline water for irrigation; and many international symposia have been devoted to this important problem. It is even proposed to use water with as much salinity as seawater (35 grammes per litre) to irrigate farmlands. In my opinion, attention should first be paid to the development of reliable methods for the irrigation of a variety of crops using water with a salt content of 10 to 15 grammes per litre. This would be of great economic value and would bring new life to very extensive regions.

Desert dwellers get water from great depths by digging wells. I once saw a well 880 feet deep made by a man who could neither read nor write. In the desert and arid regions wells over 300 feet deep are not a rarity.

One of the most remarkable devices for getting water in the desert is the underground tunnel or gallery known by different names—kiariz, kanat, fogghza, etc.—in different lands. But whatever the name, the principle is always the same.

Iran offers the best examples of the kanat technique. It is hardly likely that anybody has ever counted all the existing tunnels, but there are said to be some 30,000. Many thousands of communities, large and small, in an area stretching from North-West Africa to the eastern extremes of Central Asia, rely on kanat water for all their needs, expecially for irrigation. The total length of these tunnels is probably over 300,000 miles. Even if this figure is not entirely accurate, the wealth of tunnels shows what a gigantic and laborious task was performed by the people of these arid regions in their search for water.

In the kanat or kiariz technique the water is collected underground in hilly areas and is brought through long tunnels by the force of gravity until it reaches ground level in lower-lying areas. The extensive networks of kanat tunnels in places where nothing on the surface reveals the presence of ground water are a tribute to the creative genius of the desert peoples. Today, in regions where electricity is too scarce to be used for raising water, the kanat would certainly prove its worth. Kanats can also be combined with drilled wells to increase the water intake.

THE search for fresh ground water in the deserts is of first-rate importance and although initial prospecting costs are high they are usually justified by the results. Western Turkmenistan for instance, a big industrial area with oil wells, railways, towns and ports, relies entirely on subsoil water drawn from the "waterless desert". This still-developing area will continue its economic expansion with the help of underground water.

In the desert regions of the U.S.S.R. a new method of locating fresh water has been developed. This is a

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Fantastic reservoirs of the lower depths

variation of the already widely-employed radio-prospecting technique of geophysics. Radio waves reflected from the surface of the underground water (the angle of reflection varying according to its salinity) are picked up by an aircraft flying overhead. Engineers are thus able to find concentrations of underground water and assess the water resources of wide areas rapidly and effectively. There are great possibilities for further development in this technique.

It is obvious that economical ways of assessing the amount of underground water contained in such aquifers must now be found. The various electrical prospecting methods now being used reduce well drilling to a minimum, but these methods can only be used to locate water concentrations relatively close to the surface. Desert geographical conditions have a direct influence on many characteristics of the upper layers of underground waters, especially their high salinity; but they probably have no effect at greater depths. Thus in the desert, as elsewhere, there may be both fresh and mineralized waters at great depths.

If the desert is close to a mountainous region in which rainfall is plentiful in an otherwise arid zone, the mountains with their bare slopes and sparse vegetation will supply water to replenish the underground waters of the desert lowlands. Some examples are the huge artesian basins adjoining the Tian Shan mountains in Central Asia, the Altai mountains of southern Siberia and Mongolia, and the Atlas Mountains in Morocco.

IF local water resources are to be used for the further reclamation of the deserts, their development will depend on our learning far more about the lower geological strata than we know today.

Until 1940, engineers considered that detailed topographical and geological charts were indispensable as guides to the test drilling that precedes more comprehensive studies and the actual construction of water-raising installations. To produce such charts takes a great deal of time and money and today simpler methods may be used.

Aerial photographs enable scientists to divide the earth's surface into its natural divisions and determine the most likely distribution of the upper layers of underground water. The general distribution pattern of deeper waters may be gauged from geological structure charts similar to those used by oil prospectors.

The oilman first looks for geological structures where oil is likely to accumulate and when he has found them he begins looking for the oil itself. Using the same technique the water prospector will probably meet with greater success, for there is water in all permeable rocks. Charts of this type can be compiled from regional seismic and gravimetric data. More precise information can then be obtained by any of the various electrical

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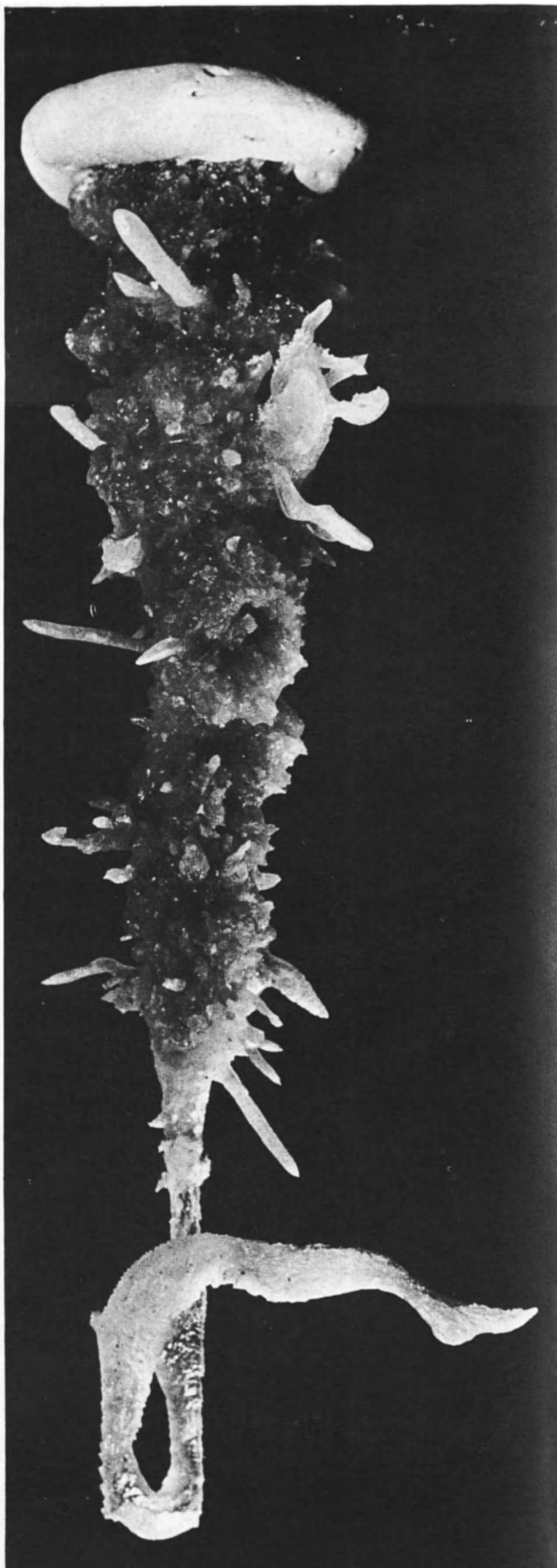
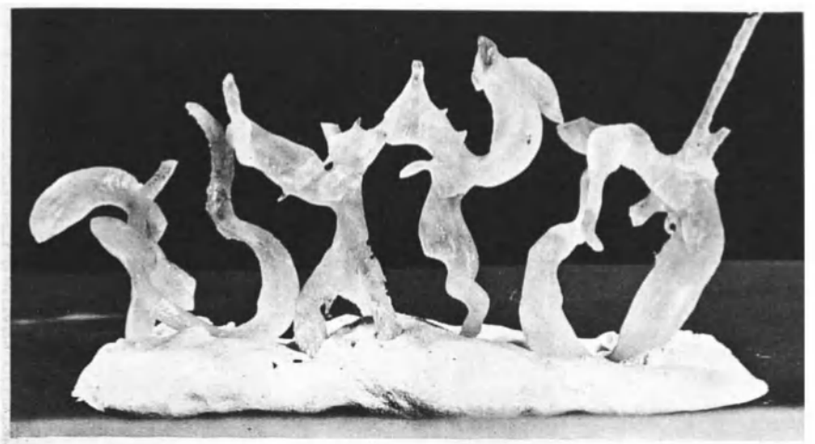
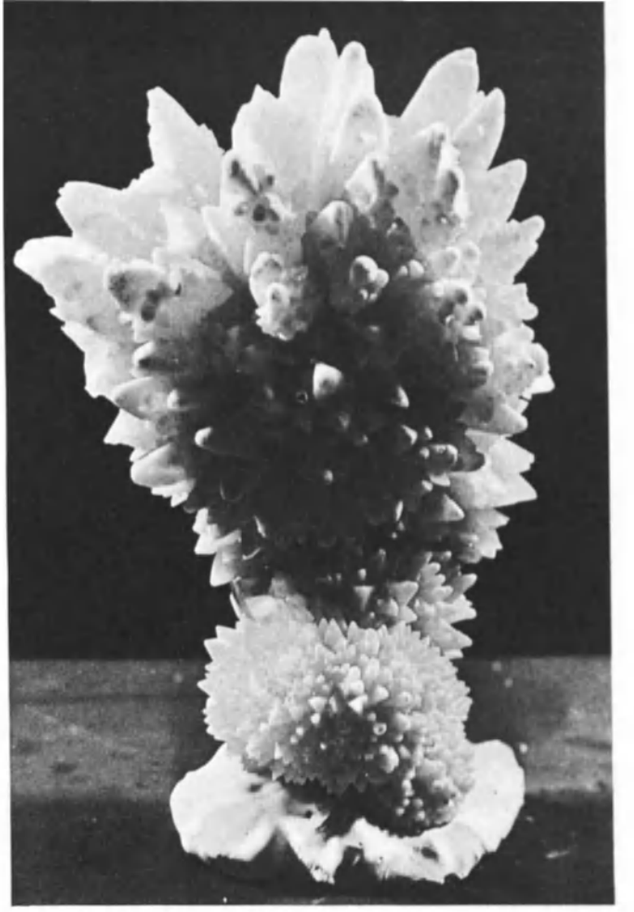


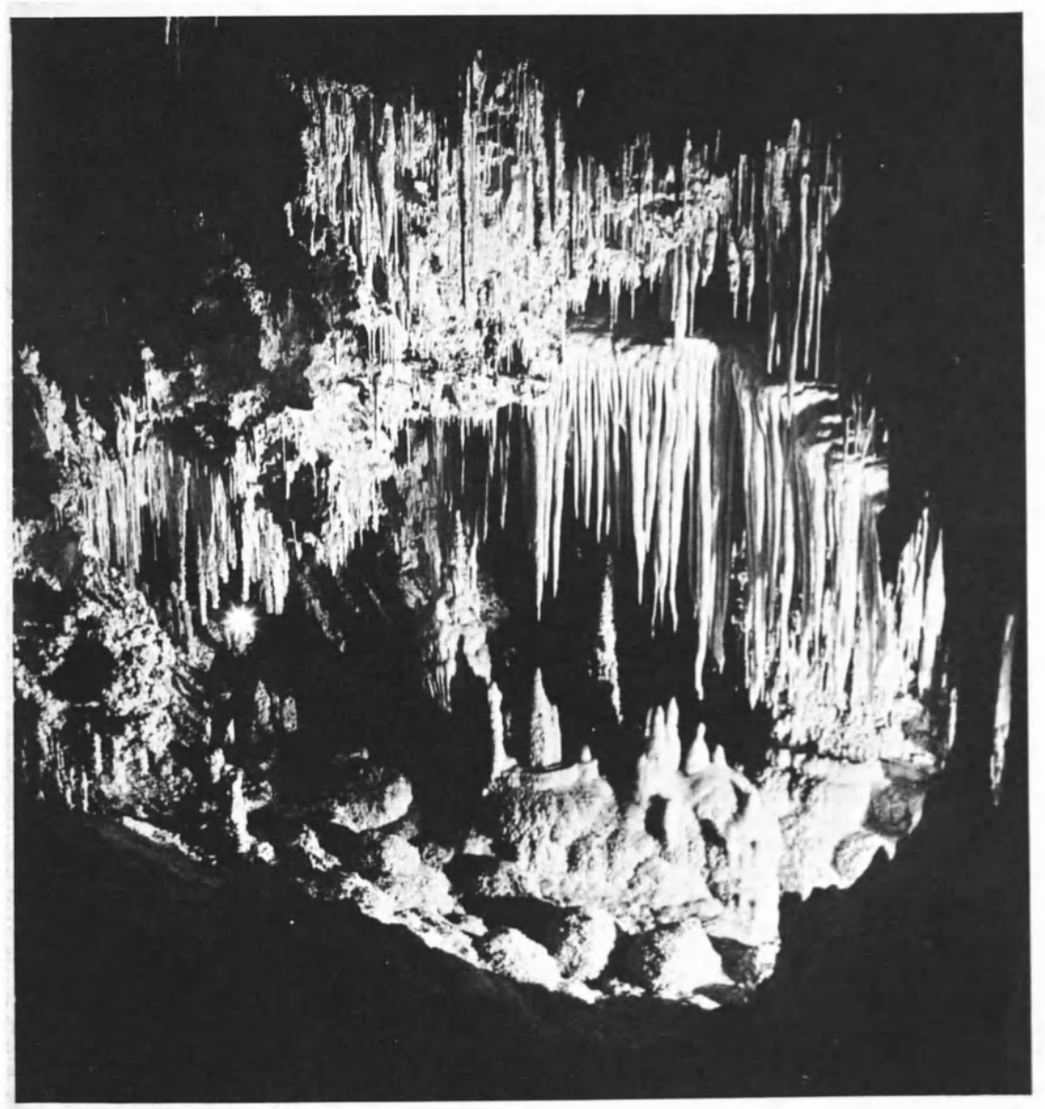
These forms sculpted by the hand of nature, from a collection made by the speleologist, Norbert Casteret, are now on view at the Fontaine-de-Vaucluse Museum in southern France. Below left, stalactite with an "eccentric" ending. Below, "ballet" of calcite deposits. Right, a "cauliflower" stalactite formed by water impregnated with aragonite, a carbonate of lime.

Photos © Reporters Associés, Paris





SCULPTURE WITH WATER



In the darkness of the world's caves and grottos, centuries and eons of time have chiselled out graceful pillars and draperies in stone. These mineral deposits are caused by water seeping through porous limestone rocks. Dripping from the ceiling of a cave, the water leaves particles of lime. In time a " stalactite" is formed, hanging from the roof. The drops deposit more lime as they splash on the floor of the cave and so form "stalagmites" which point upwards like icicles in reverse. Sometimes stalactites and stalagmites join together to form pillars. When infiltrating water runs down the cave walls it forms stone curtains or drapes, as in the cave of La Clamouse, at St.-Guilhem-le-Désert in the south of France (left). As the other photos show, these stone formations can take on far more eccentric shapes. This happens when the drops of water are diverted to one side or when air currents in the cave produce more evaporation on one side of the mineral formation.

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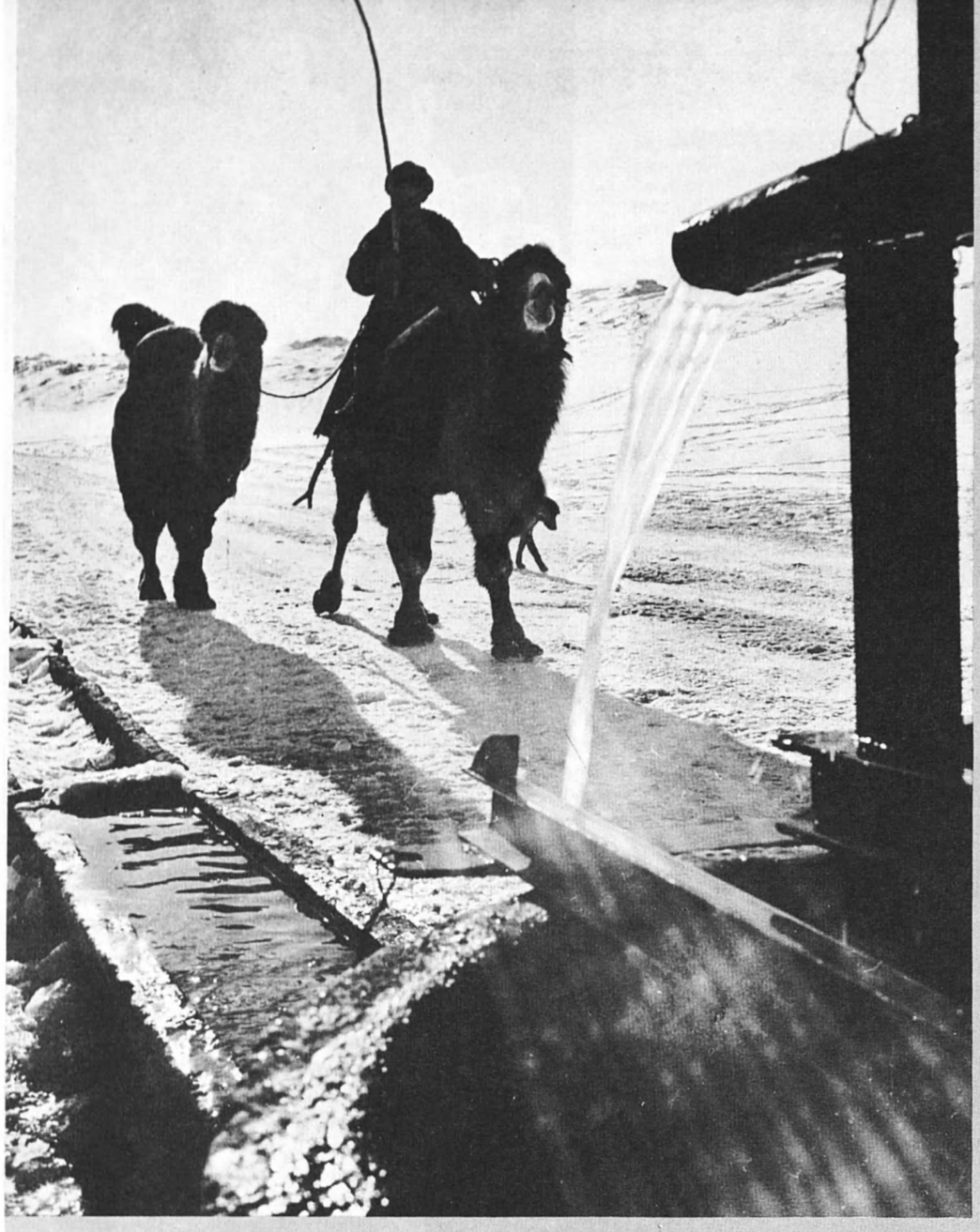


Two-humped Bactrian camels from central Asia.

THE THIRSTLESS CAMEL

The Unesco Courier draws its readers' attention to a most beautiful book just published entitled "Animal Worlds" by Marston Bates portraying the infinite variety of animal homes to be found on land and in the waters of our planet. Recommended by the World Wildlife Fund as "not only a thought-provoking and beautiful 'art book' but an authoritative introduction to natural history, the book emphasizes that the destruction of the animals' world is the path to destruction of man himself." The text is supplemented with 242 illustrations, 100 in full colour by some of the finest wild life photographers. Published in the U.S.A. by Random House Inc., New York. ($15) and in Great Britain by Thomas Nelson & Sons Ltd. (84/-). The text alongside is reproduced from "Animal Worlds", © 1963, Random House, Reproduction prohibited.

A.P.N.

WASTED TREASURE *(Cont'd)*

Water galore — if we're wise

prospecting methods; if this plan is used the amount of test drilling is greatly reduced and the data obtained shows the filtration properties of the area selected and the degree of salinity of the water.

Some major problems, however, still remain. How much water is available ? What indications are there to warrant further large-scale prospecting and an assessment of quality? This aspect of the work is the most difficult and the most expensive; it is here that science must provide new methods of investigation that will radically change the situation.

We possess simple and cheap methods of estimating atmospheric precipitation and surface run-off. It is not difficult, for instance, to calculate the approximate rainfall over an area with a given geological structure, and to assess the amount of water that has escaped beyond the boundaries of that area. We cannot, however, say how much of the water has gone to replenish underground water because we have no cheap and reliable methods of measuring infiltration and evaporation over large (or even small) areas.

THE present gap between scientific knowledge and the needs of man should soon be closed. We shall then be able to use the balance method (the ratio of water runoff to rainfall) to assess the amount of water in each geological zone that goes to replenish underground water. Thus we shall have more precise knowledge about the water resources on which prospecting and other search methods should be used. Scientists maintain that the water-balance method can become a universal technique of assessing water resources. But this method will only become the cheapest and most rapid

AS everyone knows, there are two living species of camels: the larger, one-humped dromedary of North Africa and Arabia; and the two-humped, hairier Bactrian camel of central Asia. These are geographically widely separated from their nearest relatives, the llamas of South America. Many kinds of fossil animals of the camel type, however, are known from Europe and North America, showing that at one time they were a common and widely distributed group of grazing animals. Our present camels and llamas, then, are relics surviving from the geological past. Why they survived, or why all of the others became extinct, is anyone's guess.

ONE can argue as to whether any of the present-day camels are truly wild. Or on the contrary, one can maintain that no camels are truly domesticated. The latter line of reasoning, used by many people experienced with camels, is that camels are simply stupid enough to allow men to use them—up to certain limits. The stories of camel stupidity and obstinacy are endless enough, and maybe it was this low I.Q. that led to their extinction in all parts of the world where no one bothered to look after them. There are, to be sure, herds of two-humped Bactrian camels wandering over the plains of central Asia, but these wild animals look no different from those raised by men, and the two interbreed freely. In the case of the African dromedaries, any apparently wild animals are supposed simply to have wandered off from some camp or caravan.

Stupid or not, camels have been very useful to the peoples of the Old World desert areas, carrying considerable loads for days across waterless terrain. How large a load they can carry, and how many days they can go without water, depend on who is telling the story—and probably also on the camel and on the weather conditions. Camel facts are scarce, which is what led Knut Schmidt-Nielsen to study their physiology.

Schmidt-Nielsen [a Norwegian scientist, working with a subvention from Unesco—see "The Camel, Facts and Fables", Unesco Courier, Nº 8-9, 1955] found that in the cool winter months in North Africa, grazing camels were not watered at all; they got all of the water they needed from the plants they ate. He decided to see what would happen if a camel were put on a very dry diet; for this purpose he tried thoroughly dried dates stuffed with peanuts. Camels, it developed, do not take to new food easily, but he finally got one animal to eat this diet, until the oasis where he was conducting the experiment ran out of peanuts. It turned out that in cool weather a camel could go for several weeks without drinking even on this dry food, but it steadily lost weight. Camels, Schmidt-Nielsen discovered, could lose up to 25 per cent of their body weight without apparent ill effect. When offered water, however, they would rapidly drink enough to bring their weight back to normal: one animal drank twenty-seven gallons of water in ten minutes.

The water is not stored in any particular place—not in the hump, which is pure fat, nor in the stomach, though this always has digestive juices. Like the kangaroo rat, the camel manages by being very economical in its use of water. The urine is highly concentrated, and sweating is greatly reduced. Camels meet the sweat problem by not trying to maintain a steady body temperature. On a warm day, body temperature wil rise up to 105 degrees F. before sweating starts; during the cold night body temperature drops, so that it may be as low as 93 degrees F. at dawn, which gives the animal a head start in meeting the heat problems of the day. Body temperature fluctuations, however, are much smaller in the case of animals with free access to water. The camel's hairy coat also serves as insulation against the heat of the day, an animal that was shaved produced 60 per cent more sweat to control body temperature than animals with normal protective hair covering.

DONKEYS are also fairly successful animals in dry country, and Schmidt-Nielsen decided to compare them with camels. He found that under similar conditions, a camel could go for seventeen days without drinking, a donkey for only four days. The donkey maintained a much more constant body temperature and had to use sweat for this. Both could lose up to 25 per cent of the body weight, but the donkey could get it back much faster by drinking—in two minutes instead of the camel's ten. It would take a man several hours to drink an amount of water equivalent to a quarter of his body weight. **Marston Bates**

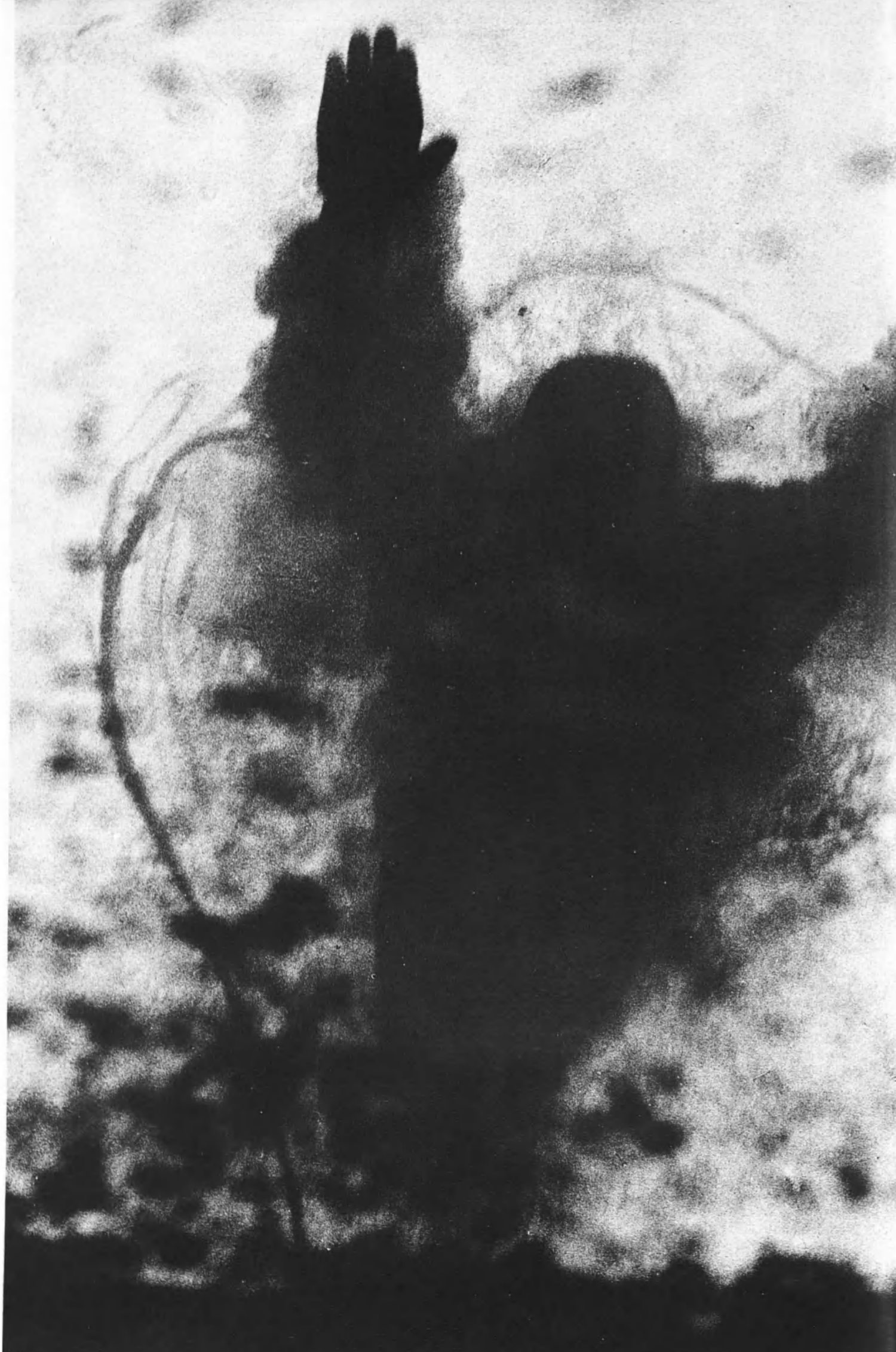
if an extensive network of observation stations is set up, well equipped with automatic apparatus. The forthcoming International Hydrological Decade should help solve this problem.

There is a saying "Great oaks from little acorns grow". Care of water is one of the little things that can prevent a great disaster; in the arid areas the upper level of underground water is often polluted through the wells, and if the flow of water from artesian wells is not regulated by stopcocks much of the water is wasted.

In terms of waste, the chief water user, irrigation, is also the chief water waster. In many countries a huge amount of water from main canals and irrigation systems is used unproductively; more is wasted in the fields and reservoirs. The greater part of this lost water flows to the underground waters and raises their level, producing secondary mineralization and bogs. Thus, not only is fresh water lost; it reappears as an enemy. The universal introduction of scientific principles and technical improvements into irrigation are an essential condition for the conservation of surface and underground waters in those areas where water is scarce.

Man need have no fear of a water shortage. All that is needed to ensure practically unlimited supplies of water is a wise and rational approach to the problem and to the use of all types of water resources. The long-term prospects for water seem promising. They undoubtedly will be if we are able to use most of the water circulating in the land part of the globe and to reduce the amount of fresh water flowing into the ocean. The evaporation from the surface of the ocean will not be noticeably reduced and the total rainfall on the land surface will remain at approximately its present level. Fresh-water resources will thus be considerably increased.

VLADIMIR N. KUNIN, *a leading Soviet specialist in hydrological problems of the arid zones, is a member of the Unesco Advisory Committee on Arid Zone Research. Since* 1937 *he has worked at the Geographical Institute of the U.S.S.R. Academy of Sciences in Moscow, and has contributed many papers to the Academy's publications. He has made intensive research into water resource problems of the central Asian deserts.*



With rivers and lakes permanently used as sewers, water pollution is a growing cancer of industrial society. Once limpid streams are now foul-smelling and filled with scum and filth. Water pollution seriously threatens public health, has annihilated whole population of fish and other water creatures and has ruined countless holiday resorts for swimming and aquatic sports. In Finland thousands of lakes are totally polluted. Lake Geneva is "off limits" to bathers in many places etc. Drinking water though "purified" chemically is often disagreeable in flavour as this Paris "water taster's" grimace testifies.

Photos © Paul Almasy, Paris

CAN WE STOP THE CANCER OF RIVER POLLUTION?

by René Colas

ONE of the unwelcome features of modern civilization is the mass of waste and refuse it seems to produce. Refuse from all kinds of human activity—industry, agriculture, recreational pursuits even—has actually become a kind of yardstick with which to measure the degree of civilization reached by any community or country.

The problem of refuse disposal, of course, is one that has faced man throughout history. But in the past the solutions adopted were usually much simpler than those demanded by modern sanitary rules and regulations. In medieval times, for instance, refuse was often simply dumped into the street where it helped to touch off many a devastating epidemic.

Confined within their defensive ramparts, the cities of the middle ages had often no alternative but to live literally on top of a garbage heap. The surprisingly high level of some Paris streets above their surroundings is simply due to the amount of rubbish and refuse left there in days that are perhaps not so distant as one would imagine.

The problem was not the same in the countryside where by a natural transformation process refuse was eventually returned to the soil—as it still is— and became a valuable fertilizing agent. Today too this process is the very basis of good soil preservation in some countries.

But the unpleasant image of piles of refuse being left to rot in the streets of medieval towns tends to obscure the fact that even in ancient times some cities had a sewage system whose design and construction had much in common with our modern installations. And even in those times some refuse found its way into the rivers, though only in quantities which the self-purifying qualities of these waterways were able to handle, thus rapidly restoring the natural biological balance.

In early 13th century Paris, during the reign of Philip-Augustus, the waters of

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Service de la Navigation de la Seine - Chevallier

Detergents have become one of the chief agents of water pollution. At locks and weirs where water is troubled, the detergents are whipped up into masses of foaming suds like those above, near the locks on the River Seine at Mericourt, between Rouen and Paris. Below, waters of the Rhine polluted with oil wastes. Even one thirtieth of an ounce of oil products can make 200 gallons of water sufficiently poisonous to kill aquatic life and also unfit for domestic uses.

A NEW CULPRIT : DETERGENT SOAPS

Studies have shown that the worst agents of pollution are the world's big cities with their huge output of sewage water. The greatest offenders are of course those capital cities which have been built on the banks of rivers.

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In recent years the use of detergents in the home and in factories has increased tremendously, and the results can be seen in rivers and lakes in which the presence of detergent products is revealed by masses of foam. This is formed when even a minute quantity of detergent is present in the water.

The products which make dishwashing and the laundry so easy are poisonous for aquatic animal and plant life. Water plants turn brown and lose their leaves when water is invaded by even a microscopic amount of detergent. Slightly higher concentrations kill off the tiny water animals which form the foodstocks for many fishes, and even tiny fish themselves.

Detergent manufacturers are trying to reduce the amount of foam produced which inconveniences industry just as much as the housewife with her washing machine.

But sanitary engineers are worried by the appearance on the market of detergents which produce little or no foam. Though the evidence of pollution will be reduced, the toxic effect of the detergents will in no way be lowered.

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The water in lakes and rivers is only renewed very gradually by the cycle of nature and this is an important reason for stepping up the battle against pollution.

The waters of Lake Constance, on the frontiers of Germany, Switzerland and Austria, are renewed every four and a half years. But as water does not flow into the Rhine from every part of the lake the complete renewal of the waters may take even longer.

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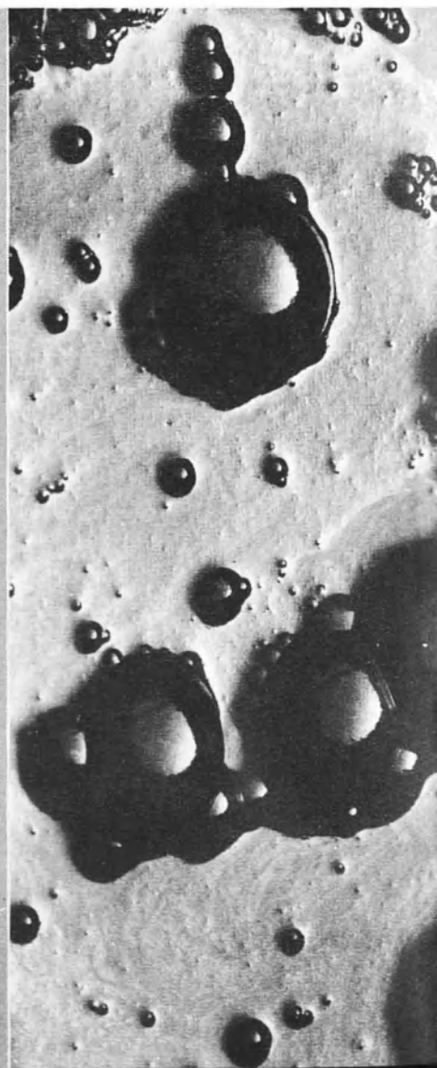
Water pollution costs the United States over one thousand million dollars every year. An effective campaign against water pollution might cost as much as 600 million dollars, but this would still leave an overall saving of 400 million dollars.



Waters that die a slow death

WHO - Jean Mohr

the Seine were crystal clear and from the bridges a passer-by could see the fish swimming between the stones and the green plants carpeting the river bed.

In London, at the turn of the 17th century it is reported that between sessions of Parliament, one of the pastimes of the honorable members was to fish for salmon in the Thames.

Gradually, the waste disposal networks expanded, and at the same time as towns organized the collection of domestic garbage they also arranged for the systematic discharge of waste and cess waters into rivers.

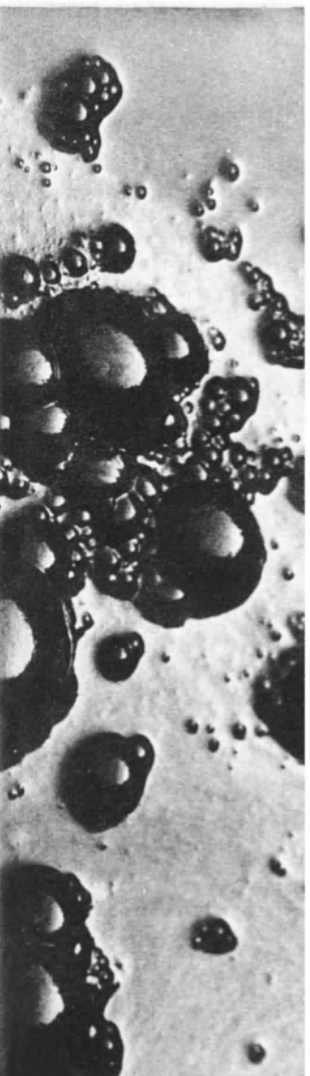
The spread of the "sewage system", combined with the progressive use of sanitary equipment—lavatories, bathrooms, washing machines, etc.—has consequently sent all waste waters into the rivers where, thanks to the introduction of refuse-grinding devices in the home, they may soon be joined by much of our domestic garbage.

Any increase in urban population causes a corresponding rise in industrial production. And, as industry develops and production processes grow more complex, water consumption increases at an even faster rate than population growth itself.

While, in the developing countries, the total annual consumption of water per head is between 200 and 260 cubic yards, nations with industrialized economies are already using between 650 and 800 cubic yards of water for all purposes and today the annual per capita consumption in the United States is nearly 2,000 cubic yards—a figure which is expected to rise to over 2,600 cubic yards within the next 40 years.

Much, if not all, of this water is discharged with all kinds of polluting elements in it: viruses, microbes, organic matter, floating particles.

Once the mass of pollution discharged into a river exceeds a certain amount the river is no longer able to destroy it. All animal and vegetable life disappears. The river is transformed into an open sewer: it dies.



THIS has been the case just outside Paris where, in certain years, the Seine has flowed downstream as a mixture of half water, half sewage.

So, when we add up all the possible sources of pollution—industrial waste in the form of chemical products, toxic elements, particles that give water an unpleasant taste, oil discharged by shipping and the increasing quantity of detergents—it is easy to understand how river water becomes unsafe, not only for drinking but even for industrial use. This situation has coincided with an increase in demands for good quality water, and when towns, finding underground water sources insufficient to meet these demands, have been compelled to turn to rivers for their drinking water.

The case of Paris is typical of many large cities. During the 19th century, spring water was brought into the capital via aqueducts which, for the time, were models of hydrological design and engineering. Until the early part of the 20th century, Paris managed with the water that came through these ducts from 60 and even 120 miles away. But the day came when Paris was obliged to introduce into its supply network water from the Seine, which up to then had been used only by industry. Full precautions were taken by slow filtering and then sterilizing. This was originally intended to be merely a reserve supply for the summer, a time when water sources diminished while consumption increased. But the needs of the capital quickly grew; buildings were modernized, new urban areas were being developed and the suburban population was increasing all the time.

Since there was no room to extend the filters or build new ones, the only way to treat the increased supply was by introducing stronger purification techniques: chlorination and ozonization. The quantity of water from the Seine and the Marne supplied to Parisian homes thus gradually increased, while that of spring water remained virtually the same.

A few years ago the low-water period of the Seine coincided with a marked drop in the spring supply. This created a critical situation and almost caused a breakdown in the Paris water supply. In the suburbs water was distributed by water tankers and in some places was sold in large bottles and even by the litre.

On one occasion Parisians complained bitterly about the Seine water they were drinking because of traces of chlorophenol which were produced by the combined effect of chlorine used for purification and phenol discharged into the river by a factory. This problem was overcome by using chlorine dioxide and by stopping the factory from discharging any more phenol into the Seine.

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UNESCO ARCHIVES

Six million tons of filth

On another occasion an abundance of microscopic water plants in a tributary of the Marne again affected the taste of the water and also seriously hindered the fuctioning of the filters.

Though in every case purification measures were taken, the people of Paris lost confidence in their water supply and the sales of mineral water and bottled table waters soared.

At the recent Congress on Hygiene held at the Pasteur Institute in Paris the quality of the city's drinking water was again strongly criticized and plans were put forward for the construction of a new supply network to provide drinking water of exceptionally high quality. This would meet a daily need of five or six litres per person and would provide for other purposes water free from harmful bacteria but possibly unpleasant to drink.

Quite understandably, these proposals were considered Utopian by the specialists at the Congress, who finally voted for a system that would provide a single quality of water—the best. Such examples illustrate the water supply difficulties which all towns are up against today.

SOMETIMES situations become so critical that towns have to consider regenerating part of their used water so that it can be reintroduced into the supply network after being treated or purified naturally.

This recycling is already practised in some industries whose water supply is inadequate and in some cases such water is recycled nearly 100%. In industry as in public utilities, however, this technique is limited by the increase in the amount of dissolved salts. Care must be taken to ensure that the limits laid down in nearly every country regarding the salt content of drinking water are not overstepped, and that strict standards of water cleanliness are maintained.

It is here that new methods currently being studied and applied for removing salt from sea water and brackish water so as to help supply arid regions can be used. The use of integral regeneration processes contemplated for space travel is also being studied.

We know that some underground water sources have still to be prospected and a better distribution of water resources, with dams and intercommunicating channels between river basins, would satisfy growing needs for some time to come.

Few people realize, for instance, that water flowing in all French rivers totals over 220,000 million cubic yards a year, of which only between 26,000 and 32,000 million cubic yards are actually used by man? From the Loire basin alone about 13,000 million cubic yards flow unused to the sea each year.

But obviously the battle against pollution is still a vital and urgent task. Some countries have already realized this and have introduced regulations and taken firm action to combat the disastrous effects of pollution.

THERE are, for instance, institutions in the Federal Republic of Germany which control the water administration in the Ruhr : "Emscher Genossenschaft," "Ruhrverband", etc. The work of the English "River Boards" has quite recently been taken over by the newly-formed "Water Authorities." In Belgium, the U.S.S.R. and the U.S.A. rivers have been surveyed and classed according to their state of pollution and in France a bill has been presented to Parliament, which provides not only for the classification of surface waters according to their degree of pollution but also for the setting up of public boards, which, in the worst zones, will help solve the overall problems of water supply and assist in combating pollution.

In the meantime the French Water Commission (founded in 1959) which actually drew up the Parliamentary bill, has established administrative machinery which will help all regions in France to carry out the enormous task of meeting the demands of a rapidly growing population and industry.

More than 20 million French town dwellers—and many people in rural areas—discard their waste directly into rivers without any purification process. The annual flow of French rivers carries with it 7,000 million cubic yards of filthy water containing polluted matter which would fill 10,000 trains carrying 600 tons each.

To this must be added the drainage from farm lands which have been treated with chemical fertilizers and insecticides, the hydrocarbons from boats and oil tankers which add to river pollution, the detergents, the rise in river temperatures caused by the discharge of cooling water from factories, and the growth of minute aquatic plants due to an increase of "nutritive

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DEADLY

About five million children die each year from intestinal diseases caused by water, reports the World Health Organization. In some developing countries as many as 90 % of the population either have an inadequate piped water service or are being supplied with water that is unsafe. Many people still have to rely on drinking water taken from wells.

At a time when ever greater use is being made of rivers and lakes for sailing, bathing, water ski-ing (above) and other aquatic sports, our waterways are also becoming increasingly polluted with the waste products of densely populated and industrialized areas. It is neither pleasant nor beneficial to go sailing or swimming in polluted water or to walk on river banks that are clogged with dirt and silt. And there are growing complaints from anglers in many places that their sport is being ruined.

WATER

rivers and other sources open to contamination with disease-transmitting organisms. For some people water is so dear that they cannot buy the minimum amount needed for adequate living. In the world's less developed areas water-borne diseases such as cholera, typhoid and dysenteries are the leading causes of death and many sicknesses.

salts" of phosphorus and nitrogen found in the water. The final picture of pollution is one which, at some periods and in some areas, has well nigh reached saturation point.

Similar situations are found in other countries, even where regulations have been introduced and public works carried out. Despite such measures these countries are losing the battle against pollution because the costs are more than they can afford.

To "clean up" river water in France and comply with current regulations would cost between £ 576 million and £ 1,152 million. And to maintain a satisfactory quality of water the annuel cost of water purification and protection would probably be between £ 14 million and £ 28 million that is, between 0.15% and 0.3% of the French national revenue.

In most countries the price paid for water by the consumer is much lower than its real value. The revenue from water charges often fails to cover the cost of supply, let alone to finance research into new resources or to promote purification of used water.

The time has now come to apply moderate increases to water supply rates and taxes and thereby maintain the quality of what is, after all, a precious element of wealth and prosperity. Perhaps too the moment has come to affirm that water is an asset belonging to all men which no individual has any longer the right to use as he pleases, and that it must be protected as the most vital of our natural bounties.

RENÉ COLAS *is director of the French Institute of Industrial Sanitation and Hygiene Technology, and is chairman of the French Water Information Centre. He is editor of the review "Eaux et Industries" (Water and Industry).*

FRESH WATER FROM THE SEA is produced in this giant distillation plant —the world's largest—at Kuwait, on the Persian Gulf. Kuwait once used to import fresh water by tanker, but in the past 15 years a series of sea-water distillation plants have been built to meet the needs of Kuwait's ever-expanding petroleum industry. ,which provides fuel for these plants—natural gas and oil.

Photos © Paul Almasy, Paris

WHERE WE STAND WITH WATER DESALTING

by Ronald S. Fenton

"WATER, water everywhere, nor any drop to drink." The words of the Ancient Mariner in Coleridge's famous poem evoke the feelings of many a shipwrecked seafarer, adrift in the immensity of the ocean, but unable to slake his thirst.

Covering three-quarters of the surface of the globe, the oceans contain practically all the world's water supply, but in a form so heavily impregnated with all the minerals that have been washed out of the land that it would be fatal to drink it in anything like the quantities normally required by the human body. Human beings only survive because a very small fraction of ocean water daily changes its form by natural processes and moves to places where men, animals and plants can use it.

If only ocean water could cheaply be separated from its salts and brought to places where fresh water is desperately needed, some of man's most pressing problems would be solved. Arid lands would be relieved from the fear of drought and in economically-developed lands the threat of water shortages due to population and industrial growth would be a thing of the past.

Conversion of sea or brackish water to fresh is not a new idea. For many centuries man has known how to do it; just boil the sea water and condense the resulting vapour. The basic method is as old as history. Starting with the Ancient Greeks, sailors have been distilling seawater in this way for over 2,000 years. Even primitive man desalted water, but in this case by evaporating the water to obtain the salt.

Wider application of distillation came with the advent of the steamship and its requirement of fresh water for boilers. Since then shipping owners have found that distilling sea-water is generally much cheaper than setting aside cargo or passenger space to store it; the difference in costs can amount to $45,000 a year for a medium-sized tanker.

DESALTING ocean water is thus no longer a problem on board ships and is now common practice. Its real significance today is for the relief of water shortages on land. That is why scientists and engineers are searching for more efficient and economical ways of converting water from the world's greatest, cheapest natural resource—the oceans—and from vast reserves of inland brackish water, into water fit for use in the home and by industry.

The technique of desalting is already well advanced. Widely-scattered land based plants now in operation have a total estimated daily production capacity of about 40 million gallons. But this is still only a "drop in the ocean"—it is no more than would satisfy the water needs of an American industrial city of 350,000 people.

The reason is that only special economic and geographical situations have so far justified the setting up of large desalting plants. One example is Kuwait, on the Persian Gulf, where vast petroleum resources began to be developed on a giant scale about 15 years ago. At that time water had to be imported by tanker at exorbitant cost. Since then a series of large-scale water distilleries has been built, fueled by natural gas and oil. Today these plants produce well over 10 million gallons a day. Yet although the fuel is virtually free, the water is not cheap compared with the cost of supplying water in many other parts of the world. But for Kuwait desalting water was cheaper than importing it.

Normally, the costs of providing water—in areas lucky enough to be endowed with a good, natural supply—are much lower than for any other commodity on earth. Thus, water supplied by desalting processes will only become competitive with water from conventional sources when technological improvements have increased the efficiency of these processes and brought down the basic costs of production.

THE stumbling block in the use of distillation to make the oceans supply the water needs of industry is the cost of providing the large amounts of energy needed for the conversion processes.

There are already encouraging signs, however, that the gap between the cost of water produced by desalting and water from conventional sources is closing up. Since 1951 intensive research and development in the United States have brought down desalting production costs, even in pilot demonstration plants, from $5.00 per 1,000 gallons to between $1.40 and $1.00, as compared with an average cost of $0.40 for municipal water delivered to the public. At the same time conventional water costs have been climbing slowly, thus further closing the gap. Some specialists maintain that within the next decade or so further technological improvements may reduce the cost of desalted water to between $0.40 and $0.60 per 1,000 gallons.

The important programme of research and development in the United States which produced these lower cost conversion results was initiated in 1952 by the Office of Saline Water. This U.S. agency was established by the Department of the Interior to "develop new or improved conversion processes . . . conduct research and technical development . . . to make engineering studies to ascertain the lowest investment and operating costs and to determine the best plant designs and conditions of operations."

Since then it has been attacking these problems with the help of demonstration plants erected in Freeport, Texas and San Diego, California (both with a daily production capacity of one million gallons) and at Webster, South Dakota. Other demonstration plants are being built in North Carolina and New Mexico. All five employ different techniques for desalting water. The U.S. saline water conversion programme is certainly the most extensive in operation today.

Another achievement in the campaign to reduce production costs comes from the island of Aruba in the Caribbean. Here, a large distilling plant has been combined with a thermal power station. Steam passes through the turbines to generate electricity and is then used to heat the sea water. About half the water produced on Aruba is used by an oil refinery, and the remainder is the sole source of supply for some 54,000 people on this completely waterless island.

Another place where it has been found worthwhile to set up a sea-water distillation plant is Guernsey, an island in the English Channel. Ordinarily Guernsey gets enough rain to produce a bumper crop of tomatoes on

CONT'D ON NEXT PAGE

Squeezing molecules through plastic pores

which its economy largely depends. But about once in every eight years a drought occurs at a critical time and the tomato crop fails. When the islanders found that for the price of crop insurance premiums they could have a desalting plant, they built one with a capacity of 500,000 gallons a day. Though it will not be used very often, it represents an investment in a cheap form of crop insurance.

Until recent times seagoing distillation plants were simple contraptions in which salt water was boiled in a kettle atop which was attached a coiled metal tube that trapped the steam and condensed it to a trickle of fresh water. Modern water stills are vastly more complex—and more efficient. Most of the heat applied to water at one stage is recaptured and transferred to the next stage to vaporize more water.

But the chief problem is still the high cost of power. Can atomic energy offer a solution? Some scientists now maintain that with further research it will be possible to combine the production of electricity and the conversion of ocean water in giant atomic power plants and thereby produce both electric power and fresh water at costs well below today's figures.

These scientists have calculated that water can be produced for about $0.25 per 1,000 gallons in plants delivering 1,000 million gallons of fresh water daily. They maintain that even this low cost could be further reduced through the use of breeder reactors which differ from present conventional atomic reactors in that they literally breed or create additional fuel supplies as a by-product.

Distillation, of course, is only one of many methods now known for desalting water and, in terms of present knowledge and experience, it is so far the most efficient and widely-used process. Distillation plants produce very pure water: less than ten parts of salts for one million parts of water. It makes little difference in cost whether the process starts with sea-water (35,000 parts per million) or brackish water (1,000 to 10,000 parts per million).

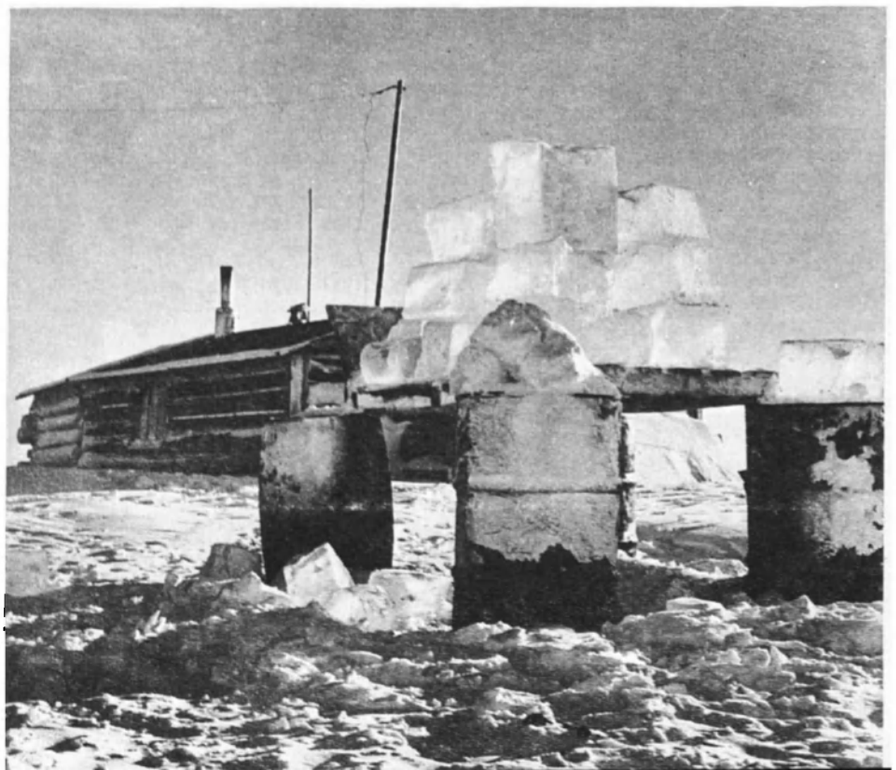
The costs of an entirely different type of desalting process known as electrodialysis, however, vary with the salt content of water. In electrodialysis the energy consumed is proportional to the amount of salts removed. Thus, where the need is to make brackish water fit for human needs it has a basic advantage over distillation. Little energy is needed to purify brackish water (typically about 2,000 parts of salts per million) to a level that meets public health standards for drinking water (500 parts per million in the U.S.A.).

Electrodialysis depends on plastic membranes that act somewhat like chemical sieves. This is how they work in the case of the common salt found in sea-water. Each molecule of salt is composed of one atom of sodium and one of chloride. When salt is dissolved in water it splits into two particles called ions—one a negatively charged atom of chloride and the other a positively charged atom of sodium. In electrodialysis the electric current causes the two kinds of ions to flow in opposite directions through banks of plastic membranes forming a series of compartments. The process leaves less salty, though not entirely purified, water in one compartment and more salty in the next, and so on down the entire bank of membranes.

The amount of salts retained in the water can be adjusted as required—to the level needed in drinking water, for instance. (Water produced by distillation is unpalatable because nearly all the salts have been removed.) Many commercial plants use electrodialysis and countries which have set up such plants include Israel, Japan, the Netherlands, the Soviet Union and South Africa.

Another promising method on which research is now being pursued is the desalting of sea-water by freezing. The first ice that forms when sea-water freezes contains practically no salt and can be melted down into fresh water. Freezing has two big advantages over distillation: less energy is required to freeze water than to vaporize it; there is no formation of mineral deposits on equipment as is the case when high temperatures are used. Offsetting these advantages are the need for expensive mechanical equipment to handle ice by the carload and the difficulty of eliminating the salt water and brine which tend to cling to the crystals of frozen fresh water. A good deal of the fresh water produced has to be used for washing the crystals. But the stage has now been reached where demonstration plants have been built and are operating on an experimental basis.

Among all the methods of desalting the simplest is distillation by the heat of the sun. Its chief attraction is that it makes use of energy supplied absolutely free of charge. The apparatus used is simple and relatively inexpensive to build. The typical solar still consists of a trough of salt water beneath a slanting roof of glass or clear plastic. The water slowly evaporates, condenses



'HARD' WATER IN THE FAR NORTH

In the Far North Eskimo wives keep their stocks of drinking water as blocks of solid ice piled up in the open air (left). When only sea water is available this can be frozen to remove the salt—a method employed in the Arctic seaboard areas of several regions. Shallow basins are filled with six inches of sea-water and when the salty water has frozen to a depth of just over half an inch, the ice is collected and the brine beneath poured away (the first ice that forms when sea-water freezes contains practically no salt). Plants which desalt sea-water by freezing are now being used experimentally in several countries.

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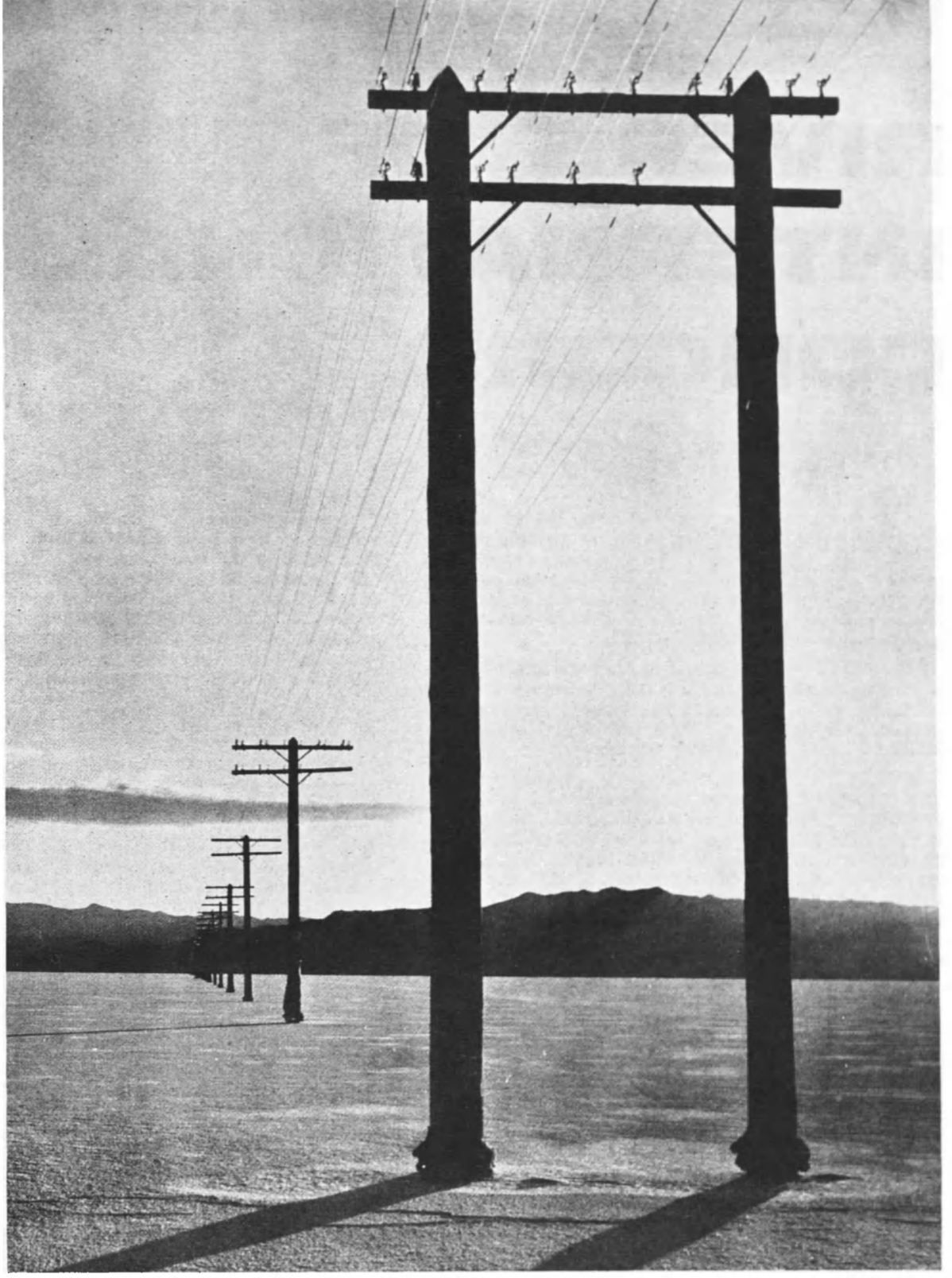


BONNEVILLE SALT FLATS in the United States stretch for miles across the northwest corner of the state of Utah. Today, an unbroken line of telegraph poles marches to the horizon and roaring motor cars set world speed records on this natural race course. Bonneville Salt Flats and the surrounding Great Salt Lake desert are the former bottom and shores of a vast fresh-water lake that covered over 20,000 square miles in this area between 10,000 and 15,000 years ago. The part of it that is left today is called The Great Salt Lake. Underground water, seeping up from below the former lake bottom, and rain waters, continuously dissolving salts from rocks, have left evaporated saline deposits estimated at more than one thousand million tons. Recovering this salt is now a major industry.

Photo Fritz Goro, from Life Magazine © 1963 Time Inc.

on the under side of the roof, and trickles down into a gutter. Solar distillation plants are naturally of the greatest value to areas that are not only rich in sunshine and poor in other fuels, but also where land space is not at a premium. They take up a lot of space if used for large-scale desalting and U.S. engineers have estimated that an installation covering 40 acres would be needed to irrigate 120 acres of farm land.

While electrodialysis and distillation have already proved their worth and freezing shows progressively encouraging results, scientists and engineers are investigating at least a dozen other desalting processes. One new line of research concerns the use of plastic membranes of a somewhat different type from those used in electrodialysis. In this process the membranes simply strain salt ions from sea-water. The pressure of a powerful pump squeezes the water molecules through the membrane pores, leaving the salt behind.

Those working on desalting research do not anticipate anything approaching an immediate major advance that would revolutionize development in their field. They are up against the hard fact that taking salt out of water has much in common with oil-refining: both involve chemical separations that demand much energy and expensive equipment.

Nevertheless, present research promises to lead to significant economies that will expand the potential use of desalted water. Development of cheaper or long-lasting membranes would cut the cost of electrodialysis. New methods for controlling boiler scale—the hard coating of mineral deposits that tends to be deposited on hot metal surfaces by sea or brackish water—would lead to increased efficiency in all distillation processes. Engineers are also trying to gain more efficiency by ingenious combinations of different processes.

Each new installation results in some improvement and paves the way for more efficient operation. The experiences with new and larger plants coupled with continued research efforts should hasten the day when more of the world's people with no reasonable source of fresh water may have access to the benefits of high-quality water produced by desalting plants.

RIVERS OF INTERNATIONAL CONCORD

by Gilbert F. White

UNTIL fifty years ago man tended to manage streams, great and small, for a single purpose affecting only a small area. True, a few ancient river structures in China and Iran served the joint purposes of mechanical water power and irrigation or of flood control and navigation, but by and large construction was for a single purpose.

Shortly after the turn of the century the idea of intergrated development of streams found currency in plans for individual water basins. The technology of moving earth cheaply in great quantities, of building with concrete, and of transmitting electricity long distances made this possible.

One aspect of the idea was to manage water for several purposes at the same place. The thirteen new dams on the Volga River, for example, serve not only to store water for navigation and for urban water supply, but generate huge blocks of hydro-electric power. The great new dam rising on the Lower Volta River in Ghana will not only provide for navigation facilities downstream but will generate power on which an alumium industry will be based.

A second aspect of this idea is that river basins increasingly have been treated as units. Instead of designing projects for solely one reach of a stream, projects for water control now are seen as fitting into a broader network throughout the drainage basin. This is the case with the Damoder Valley and other basin projects in India, in the Snowy Mountains of Australia, with most of the newer river schemes in the Soviet Union and the United States, and with the planning that is going on in a number of the basins of Latin America under the sponsorship of the Economic Commission for Latin America.

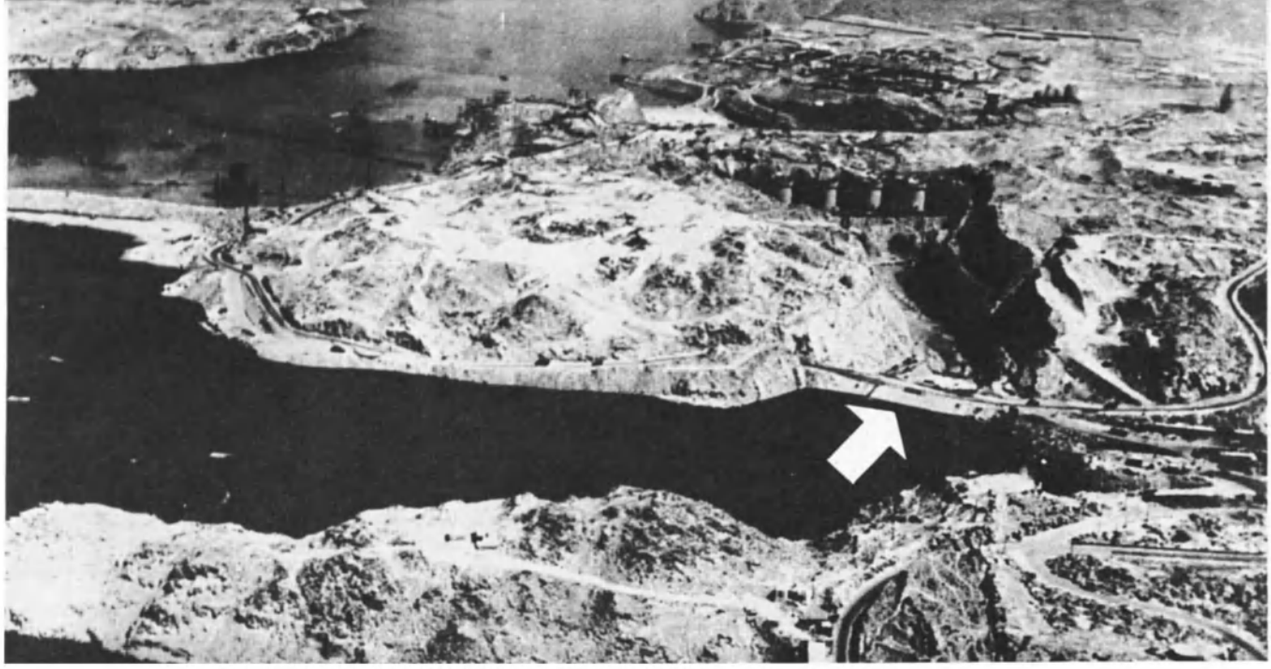
Still a third aim that has become prominent in the last twenty-five years is the vision of using large-scale water control works to affect basic changes in the life of the people of the entire region. This was the goal of the Tennessee Valley Authority in the United States which used a system of dams to generate power, control floods, and provide navigation in such fashion that soil and forest resources would be improved and the people's income and employment pattern would be bettered.

CONT'D ON PAGE 36

TEAM WORK ON THE INDUS

Down the River Indus and its five tributaries—one of the world's greatest river systems—pours an annual waterflow double that of the Nile. Some 40 million people in West Pakistan and ten million more in India rely on the Indus to irrigate 30 million acres of farm land. In September 1960 a long-standing dispute over the use of the Indus waters was settled by India and Pakistan which agreed to share them through a vast international river development plan. Eight countries including India and Pakistan, and the International Bank are helping to pay the cost of dams, artificial lakes and an irrigation system. Irrigation will no longer be at the mercy of seasonal climatic changes or fluctuations in river-flow. The project will also increase hydro-electric resources and give better flood protection to both India and Pakistan. Right, a mighty dam wall on the Indus at Gudu, Pakistan. Left model reservoir for studying sluice gate and water flow operations.

Photos © Paul Almasy, Paris



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THE NEW NILE

The first stage in the building of Egypt's High Dam at Aswan was completed on May 14 by the opening of a huge diversion canal. Here, courage and ingenuity combine to meet problems created by today's population "explosion". Two centuries ago Egypt's population numbered two and a half millions. Today it is 27 millions and by 1972 will have grown to 36 millions. For thousands of years the peoples of the Nile Valley were at the mercy of the river's whims; starvation or prosperity were entirely dependent on the vagaries of rainfall in the highlands of Ethiopia. The building of the first Aswan dam at the turn of the century and its enlargement in 1912 and 1933 were really no more than provisional measures. Now, for the first time in its history, the Nile is being completely harnessed for man's use. When completed the dam will span a distance of over 3,900 yards. and its waters will create the world's second largest man-made lake (after the Kariba Dam in Rhodesia) some 300 miles in length. The new dam will make possible a 30 % increase in agricultural production, the production of 10,000 million kilowatt hours of electricity per year to give new impulse to industry, and will ensure complete protection against serious flooding. The dam is due to be completed by 1967 and the hydro-electric equipment should be functioning by 1969. Egypt has undertaken this huge task with financial aid amounting to 1,300 million roubles from the Soviet Union which also supplied equipment and 1,800 engineers and technicians. Newly-built villages are now replacing those due to disappear under the waters of the new dam. Thanks to an international campaign launched by Unesco, funds have been collected for the biggest archæological operation of all time including the safeguarding of the temples, at Abu Simbel. The progress of this campaign and the rescue of Nubia's monuments have been described in The Unesco Courier, particularly in two special issues (Feb. 1960 and Oct. 1961). Another special number devoted to Nubia is being planned.

Al Ahram

DIVERTING THE WORLD'S LONGEST RIVER

Photos on left were taken before and after the opening of the diversion canal on the Nile, the world's longest river, during construction of the High Dam at Aswan. The flow of the Nile (from left to right) has been checked by a mainstream coffer dam (seen on left). While the diversion canal was being dug the waters of the Nile were halted by a sand dam (arrowed in photo far left). When an explosive charge broke open this sand dam on May 14, 1964, the torrent of waters began to flow in a new bed (photo left). From here they will pass through six tunnels in which hydro-electric turbines will be installed. The day the Nile waters were sent along their new course,there were wildly enthusiastic scenes (below) as technicians and workers hailed the end of the first phase in a gigantic engineering feat.

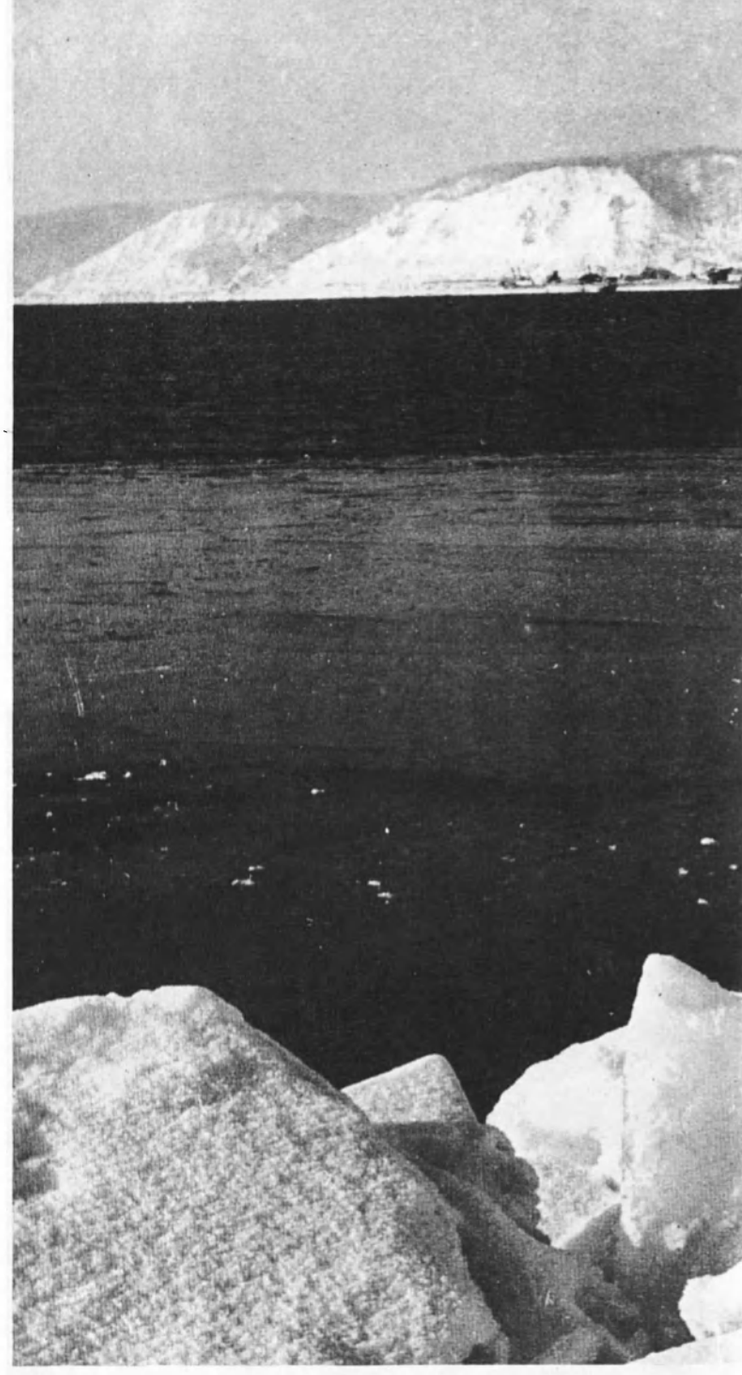
© Tass - V. Budan

The tricky art of taming nature

The idea of integrated river development now is widespread. It is applied to management of small mountain valleys as well as to huge basins reaching to the ocean. It is carried out with great care in a number of the streams of the Soviet Union, notably the Volga-Kama, Don, Dnieper, and Syr-Darya.

The United States has used this concept in plans not only for the Tennessee but for the whole upper Ohio, the Missouri, the Colorado, and perhaps most notably for the Columbia and central Californian basins. In only a few places, such as parts of the arid Colorado basin in the U.S.A. and the Ili basin in central Asia has development reached what might be considered maximum. In most basins water still flows to the sea unregulated and the power of its fall remains unharnessed. Each year, however, sees additional water regulated and additional stream reaches captured by construction of dams.

The great integrated developments have taken place chiefly on streams which lie wholly within one country or in a single nation's portion of a stream. Thus, the developments on the Rhone have been planned solely within France in the first instance and those on the Tigris-Euphrates were designed wholly for Iraq. Only a few international streams have received integrated treatment although the international streams account for a large proportion of the drainage areas of the world.



SOME of the mighty rivers of the world—the Nile, the Amazon, the Congo, the Ganges-Brahmaputra, La Plata, the Amur and others—are distinctively international streams.

Until recent years only a few of these had received unified, co-operative treatment from the countries which contribute the water and share in the opportunity to use it. The Danube has been the subject of collaboration in hydrologic data collection and navigation regulation for a long time (see photo story p. 38). Agreements for the maintenance of navigation works and, more recently, the management of polluting wastes have developed in the Rhine in Western Europe. International accords affect much of the water of the Nile.

On the North American continent after many years of negotiation Canada and the United States have agreed on related plans for the Columbia basin. On the southern border, long-standing treaties affecting the regulation of the Rio Grande and Colorado are operated by Mexico and the United States, but revisions must be considered as new conditions arise.

Perhaps the outstanding case of direct investment in an international stream is on the Indus River where under the leadership of the International Bank for Reconstruction and Development a special programme of river development has been planned by India and Pakistan with a condominium of other interested countries (see page 33).

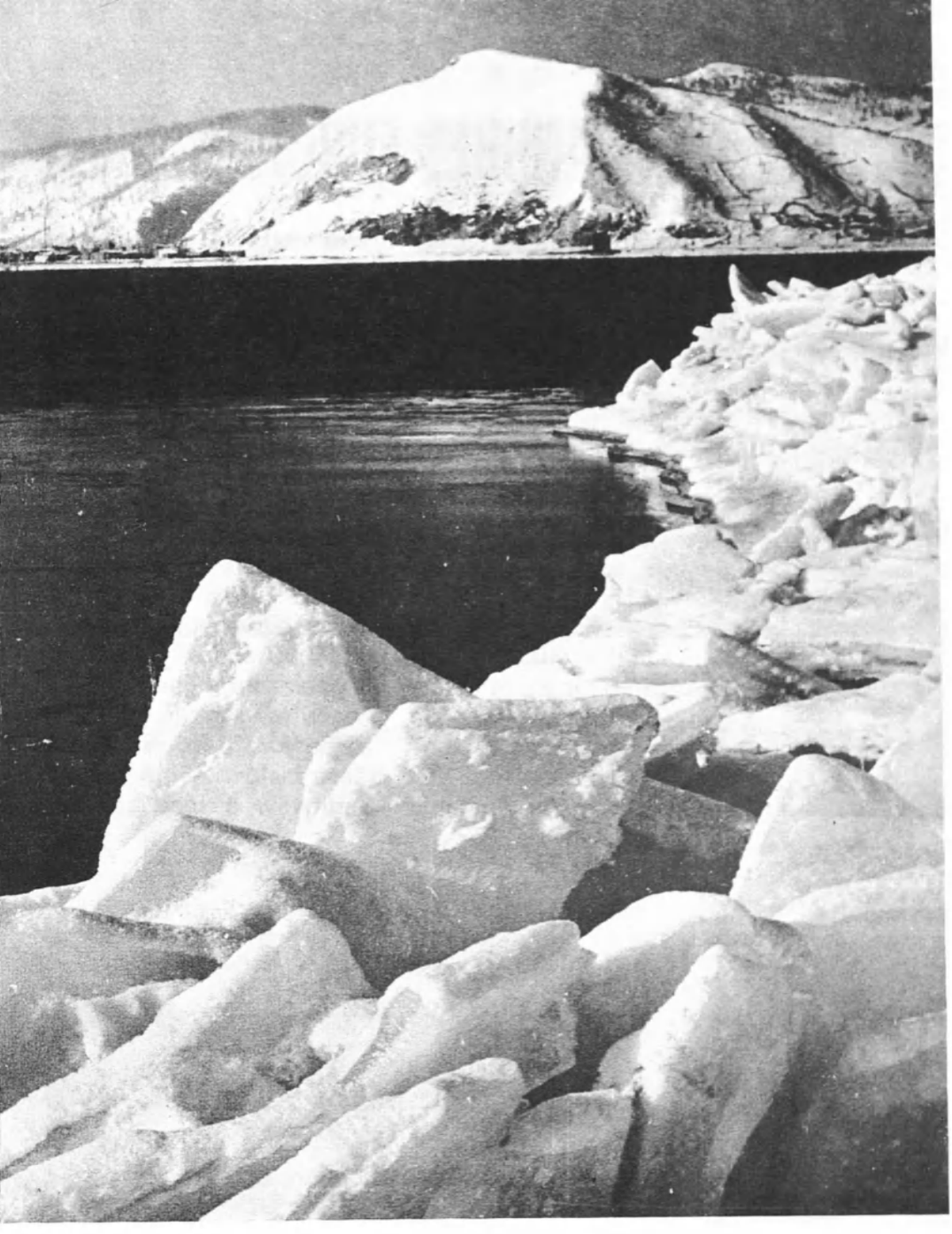
The most elaborate collaboration in planning of international river development before actual construction has taken place is in the Lower Mekong where four countries, Cambodia, Laos, Thailand, and Vietnam have joined in carrying out basic scientific and engineering studies (see page 46). In this work they have been joined by eighteen other countries and several foundations and international agencies.

It now is possible to find teams of French and Indian engineers who are designing water management works in Cambodia using maps based on Canadian air photographs, geology from an Australian study, hydrologic data from a United States programme, and reconnaissance survey work from Japan. A co-operative international study currently is in the organizational stage for Senegal drainages in West Africa, also with the sponsorship of the United Nations.

Integrated river programmes place special demands on the interlocking of scientific, technological, educational, and cultural activities. A great river basin is an extremely complex web of relationships which show themselves not only in the hydrologic cycle of water but in the movements of silt and in the movements of people and their products.

Governments have learned that when a dam is built it is more than a single structure which stores water from the flood season to be used in the dry season. It alters the regimen of the river downstream and thereby affects the flow and quality of water and the river channel. It changes the fish and plant population of the water. It may have a profound impact upon the peoples way of earning a living, and it may disturb roads, market facilities and the channels of government.

Quite aside from such instances as, for example, above the high Aswan dam on the Nile, where valuable archæo-



BAIKAL

World's deepest fresh-water lake

With its volume of 5,300 cubic miles, of water, Lake Baikal in southern Siberia is the greatest fresh-water lake in the world. It is also the deepest (5,400 feet) and has a length of 390 miles. The animals and plants found at Baikal are one of its most remarkable features. About 1,200 species and varieties of animals and about 700 plants have been found there. Some of the animals are quite unique. Baikal is fed by 336 rivers, but only one flows from the lake—the Angara River. The rain and snow that fall each year on the lake total 2.2 cubic miles—enough water to fill Lake Zurich in Switzerland twice over.

© Tass-APN

logical remains are threatened by reservoir construction, water management brings into play new forces that may profoundly alter the society which they are intended to aid. It does not always follow that a huge concrete dam, however appealing it may be as a symbol of economic development and mastery of Western technology, will yield net benefits to the area where it is built. The cost it imposes upon society may exceed the gains which flow from it.

If agricultural extension, credit and marketing facilities do not shift to help farmers use the new opportunities effectively, an irrigation structure may fail to improve their output. Moreover, it may carry the hazards of disease. Today more than 100 million people in the world are suffering from the debilitating disease bilharziasis whose spread has been largely encouraged by construction of irrigation projects which were intended to build up the economy of the very population which is debilitated by the disease.

It would be preferable before a river management project were undertaken to forecast with a fair degree of accuracy what its effects would be upon flows of water, silt, people, and income in a given culture area. Today, however, only a part of these impacts can be foreseen. The best that can be done is to marshal as much special study and judgment as can be obtained before fateful decisions are made as to further harnessing of the earth's waters.

It is not enough simply to develop engineering designs. These must be based as far as possible on accurate scientific knowledge of the phenomena of water and ecological relationships which will be changed. These effects must be measured not only in the direct costs of construction and operation, but in the broader benefits and costs of changes in productivity and culture which will result from them.

But even gains in productivity cannot be assured unless there is knowledgeable effort to assure the cultural and social conditions in which change may take place. Often this revolves upon education. Thus science, technology, social science, and education are mutually dependent in arriving at fruitful management of the earth's rivers.

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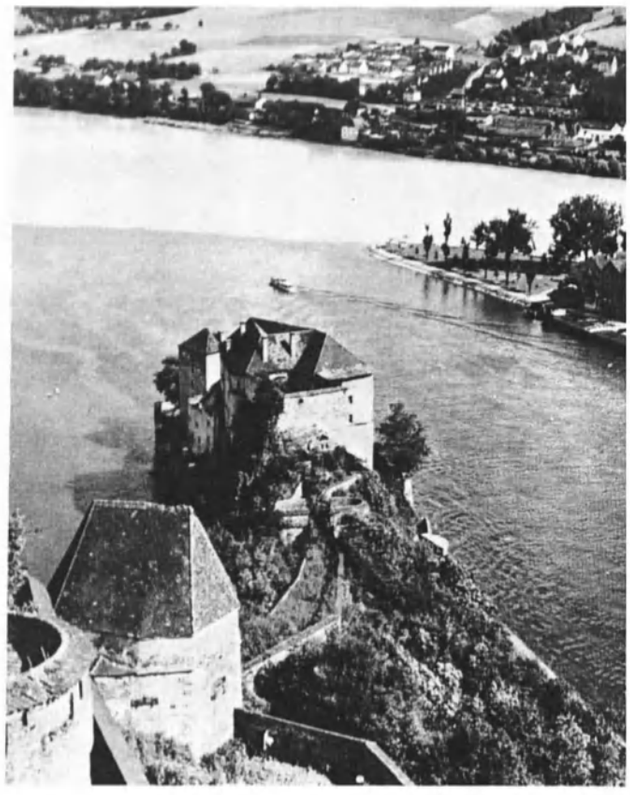
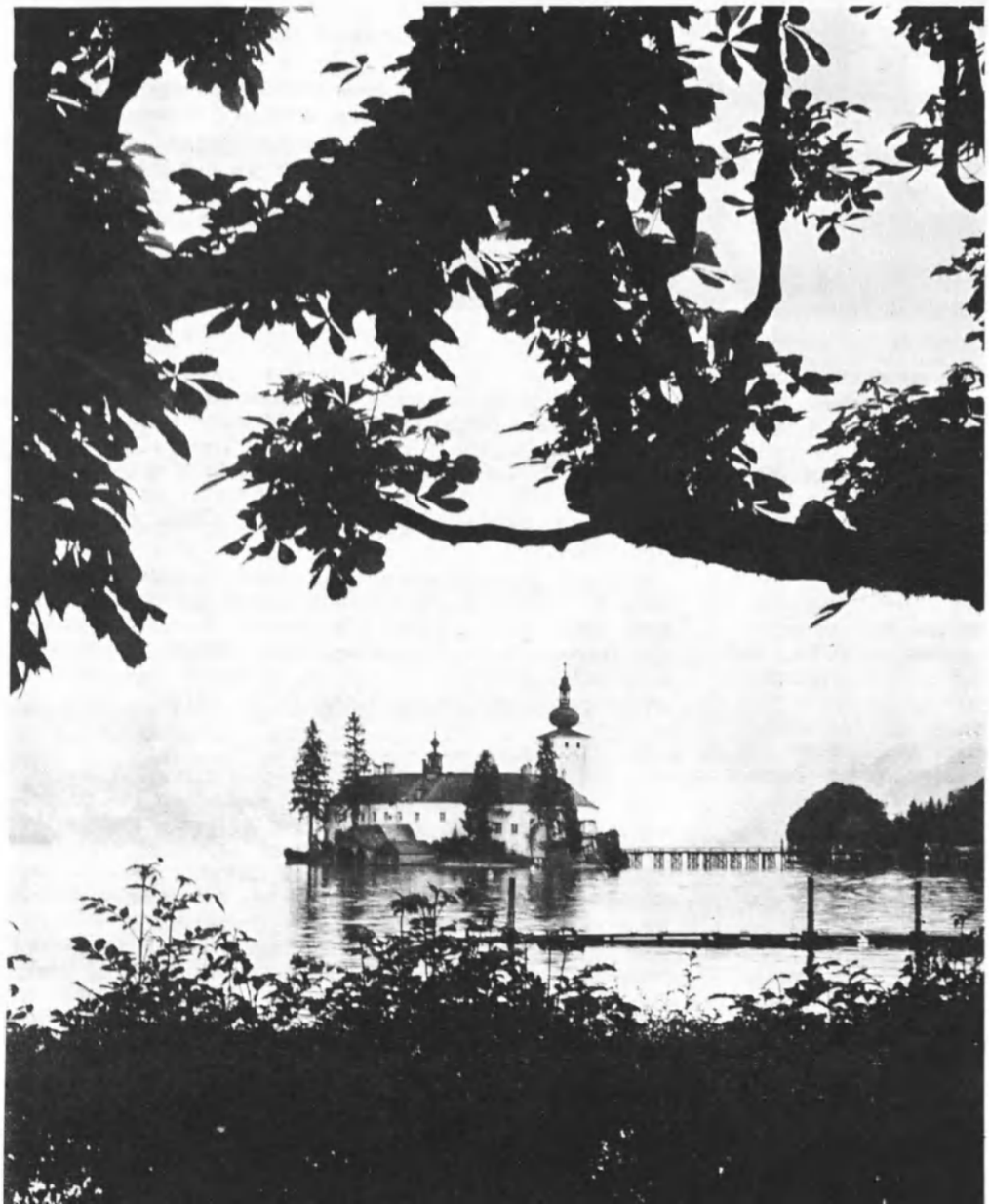
THE DANUBE, EUROPE'S GREAT

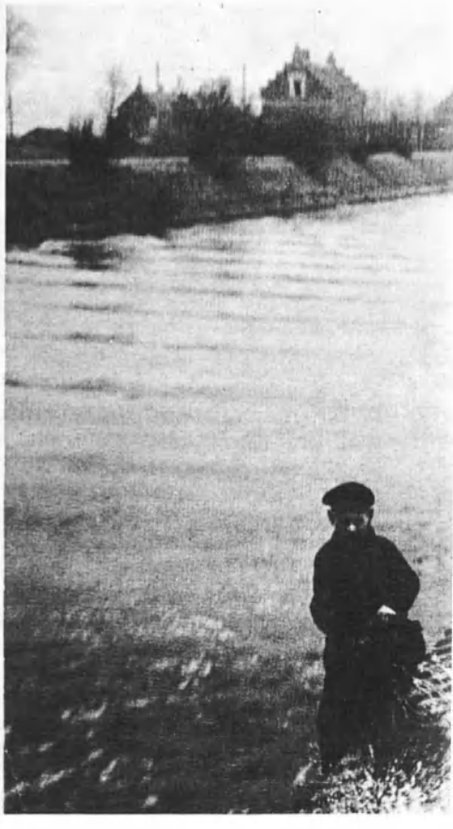


Deutsche Zentrale für Fremdenverkehr, Frankfort

The waters of three rivers—the Danube, the Inn and the Ilz—meet at Passau (Federal Republic of Germany) an ancient fortified town dating from Roman times.

In a pleasant little valley of the Black Forest, a tiny stream comes tumbling down the rocks and, gathering strength from springs and rivulets, begins to cross southern Germany. This little stream, the Brege, with its twin sister, the Brigach, is the source of the Danube—the greatest river in Europe next to the Volga, and 1,800 miles in length. The course of the Danube which passes through eight countries—the Federal Republic of Germany, Austria, Hungary, Czechoslovakia, Yugoslavia, Bulgaria, Rumania and the U.S.S.R.—has been determined by the conformation of the European landscape. The Alps, the plateau of Bohemia and the Transylvanian Alps send it in a west-east direction, and in the broad plains of Hungary and Rumania it runs from north to south and back again. The Danube gathers its water from over 300 tributaries and its basin covers an area of 500,000 square miles. Navigable throughout nearly its whole length, the Danube has been since earliest history a great water highway, a road for cul-





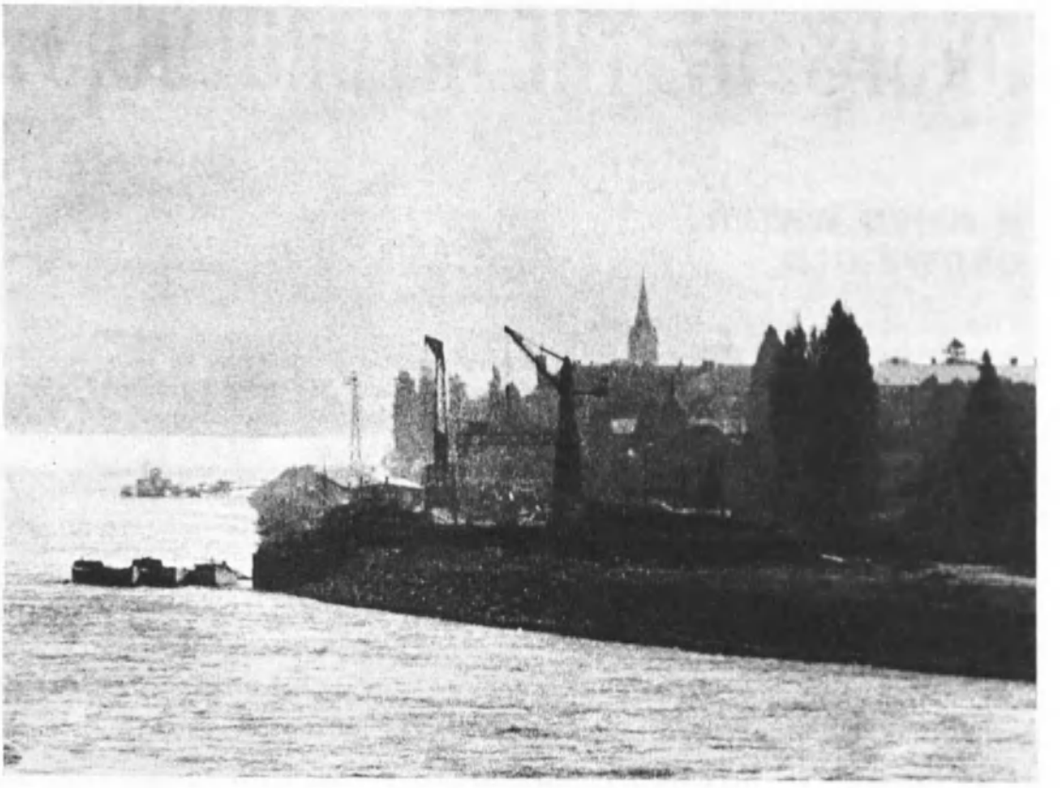
The Danube is navigable along nearly the whole of its 1,800 course, down to the Black Sea. Far right, a barge puts in at one of the many river ports.

The castle of Gmunden (left) is built on a tiny island in the Traunsee, a lake in upper Austria, through which runs the River Traun, a Danube tributary.

© Paul Almasy, Paris

WATERWAY

ture and for trade between Western Europe and the Levant. In the first century A.D. it was the northern frontier of the Roman Empire and a defence line which disappeared with the Germanic invasions. In 1856 a treaty was signed declaring Danube navigation free to all nations. From Ulm in Germany to Kilia on the delta near the Black Sea great city ports line the river and barges, towboats and rafts loaded with products of all kinds ply their way along this vital commercial waterway.



© Inge Morath-Magnum

With its banks still rich in architectural treasures from the past, the Danube has now become a vital artery of modern technological civilization.

© Leonard Freep

AUSTRIA RESEARCH PLAN The Danube basin offers a rich field for international hydrological research. Studies now being carried out by Austria, for example, not only aim at the development of this country's own hydrological resources, but also assist the long-term international programme in hydrology now being prepared by Unesco. Some of the work, described in a recent report from Austria to Unesco, includes hydrological and thermodynamic studies in mountain areas and other hydrological studies in the Danube basin. This research, of benefit to all countries along the river, covers the improvement of hydrological forecasting, erosion problems, investigations of sediments carried by the river, and studies of the effects of industrial development on the river system, including pollution problems.

DROPS IN THE HYDROLOGIST'S BUCKET

■ WHEN WATER GROWS OLD

The idea of water "growing old" is one that never occurs to most people. In the popular sense water begins to "age" from the moment it is collected in a receptacle. However water is actually "born" the moment it condenses from a cloud and falls to the earth as rain, snow or hail. Water, in fact, starts to "age" the moment it begins to run over the surface of the ground and starts from watercourse to watercourse on its way to the sea.

If it starts to infiltrate into the ground, where it will circulate and be stored, its chances of "survival" increase considerably.

Today, the dating of waters that have been stocked in the water-bearing rocks of the earth's crust for thousands of years—or perhaps only for a few centuries—has assumed great importance.

When the "water capital" of a given area is being exploited it is important for water engineers to know how far this "capital" has already been drawn upon when catchment or pumping begins. This means they must find out the ratio between the volume of water which each year reaches the water-bearing terrain—the aquifer—and the volume of water extracted from it. This gives an idea of how long the stock will last.

Nowadays underground water is looked on less and less as a fully-renewable natural resource. It tends more and more to be "mined" like ores, whose eventual exhaustion can be predicted. This calls for a change in the outlook of the user, and so greater efforts are being made to recharge the aquifer, that is, to build up its reserves by injecting water into the ground so that this can subsequently be recuperated for man's use.

Research into the dating of water enables us to follow the effect of these restocking operations on the evolution of underground reserves. Use is made of radioisotopes, such as tritium or carbon 14, to determine the age of an underground water supply.

Isotope tests have shown that large underground stocks of water may well have been deposited (especially in arid lands) during the rainy periods of the Quaternary Age when, long before the present desert climate, forests grew in the Sahara.

■ FRESH WATER SPRINGS IN THE SEA

What could be more surprising than to watch a fishing boat leave the Greek coast at Corinth, or the Moroccan coast at Agadir, and make for a predetermined spot in the open sea to take aboard a supply of fresh water?

Yet these Greek and Moroccan fishermen have long been doing this thanks to the knowledge, handed down from generation to generation, that at certain points fresh water springs in the relatively shallow sea-bed send water to the surface that is practically uncontaminated by salt.

These springs are generally fissured beds of limestone that drain surface water from the land and release great quantities of fresh water through faults or fractures on the sea-bed. Detailed studies of submarine springs have recently been made in Greece with a view to recovering these wasted water supplies for the benefit of the nearby land which is in dire need of them. The presence of the sea-water from which they emerge, the instability of the water-mass pressures and, finally, their relative inaccessibility, all complicate the task of recovery.

Geological research of the kind used to locate oil deposits on the shore or under the sea has led to the catchment of artesian pockets of fresh water beneath the sea-shore at Istanbul in Turkey and at Recife in Brazil at depths of between 500 and 650 feet. Here the techniques of the geologist have joined hands with age-old experience and knowledge of Greek and Moroccan fisherman.

© Paul Almasy, Paris

'WATERBORNE' WELL. Fishermen's wives at Ganvié, in Dahomey, draw drinking water from an artesian well which has been sunk through the bed of a lagoon to reach a fresh water pocket situated far beneath it.

USIS

RAINMAKERS. Scientists are seeking ways to control the weather. Such research may reveal ways of bringing rain to areas which now suffer from drought and of protecting other areas against floods, cyclones, hailstorms and tornadoes. Above, a cloud of ice fog produced by throwing a can of water into cold air (minus 40 degrees C.) during weather research experiments in Yellowstone National Park, Wyoming, U.S.A.

■ WATER WITH A CUTTING EDGE

The many uses of water, from its role as a basic necessity for men, plants and animals to the part it plays alongside coal and oil in supplying energy, are well known. Less well known is the fact that the power of water may be used in factories and workshops like a cutting tool, with the simple difference that it will never get worn or need sharpening.

In September 1961 the Bulletin of the Water Information Center in the United States reported that a big machine-tool factory at Los Angeles had designed and built a machine in which a fine stream of water with a pressure of over 14,000 lbs per square inch is used to cut cement, wood and plastic materials. For cleaning all kinds of metallic surfaces, this device works more quickly and efficiently than any existing abrasive material.

Basically, it is the old story of the drop of water which falls on to a stone, gradually eating a hole in it, though now adapted through new technological know-how for use in modern industry.

■ CITY BUILT ON A 'JELLY'

The centre of Mexico City, and in particular Alameda Square and the Fine Arts Theatre, is subsiding at the alarming rate of nearly 12 inches a year.

Mexican engineers blame the continuous pumping operations that go on near the city for this subsidence. The explanation is as follows:

At the beginning of the Quaternary Age, the area of Mexico City had been a large and very deep valley which was closed abruptly by a flow of lava from Mount Popocatepetl, Mexico's largest volcano.

Once sealed off, the valley rapidly became a lake between 2,000 and 2,600 feet deep. This in turn was gradually filled with volcanic ash from subsequent eruptions. Finally, only a shallow depth of water was left while deep down the ash instead of settling formed a glutinous mixture with the water until the land became rather like a jelly in consistence.

The present site of Mexico's capital was still a lake when the Spanish conquistadores arrived in the country, and when the Aztecs established their capital there they were thinking of its natural defensive advantages. But the "ground" here is actually composed of 15% of solid matter suspended in 85% water.

Pumping operations in this waterlogged earth creates a vacuum under more recent surface alluvia and gradually the underground structure is being destroyed. That explains why the stage and reception rooms of Mexico City's Opera House and neighbouring buildings sink lower and lower each year.

The city's centre is now about 35 feet below its original level, and is thus even lower than the surface of Texcoca Lake—all

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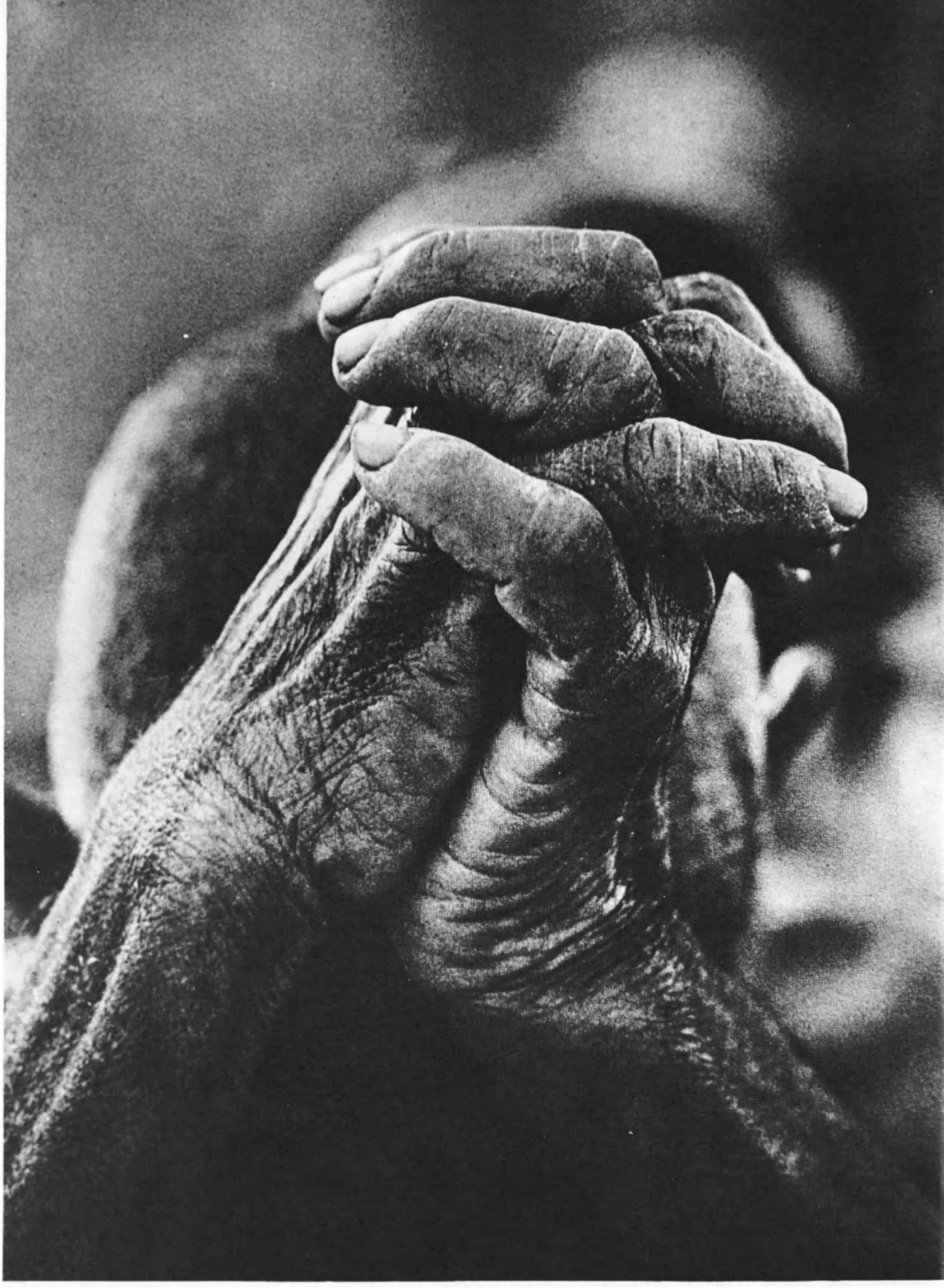


MAY THE RAINS COME

Eloquent hands speak the thoughts of an Indian farmer as he waits for the summer monsoon to bring the longed-for rains. Drawn inward by low pressure over the heated interior of Asia, the summer monsoon carries moisture from the Indian Ocean and brings downpours to countries of south-eastern Asia. All rural life in these regions is regulated by the monsoons. When the rains fail or are late, drought brings severe famine.

UMBRELLA TIME IN BOMBAY

A signboard in Bombay, India, announces the approach of the monsoon. Now the stifling May days are counted until downpours bring relief to land and people alike.

Photos © Magnum - Brian Brake

CITY BUILT ON A JELLY *(Cont'd from page 41)*

that now remains of the once vast lake on which the Aztec rulers built their capital.

This situation, coupled with one of a more geographical kind, namely that the town is situated in an enclosed inland basin, has created a serious problem of waste-water disposal for the municipal authorities. Since the basin is completely closed, the water can neither be returned into the ground nor evacuated into a canal or river. Furthermore the roads leaving Mexico City—situated at an altitude of 7,870 feet—climb up to 9,190 feet and to even higher levels before they are free to turn down the Atlantic slopes on one side or the Pacific slopes on the other.

Thus the only possible way to dispose of sewage water is to pump it out of the enclosed basin and into the Atlantic basin. How important this pumping has become can be gauged from the fact that over four million people live in the area.

The public health services and the government itself keep constant watch on the multitude of pumps used for this operation for a general breakdown would allow invading sewage waters to flood the city to first floor level within 24 hours.

■ DEW MOUNDS AND 'LILY RESERVOIRS'

The ancient peoples living in desert areas built "dew mounds" of large flint pebbles around each fruit tree and vine to attract the dew and convey it quickly to the roots of the plants.

Today, people still find ways of collecting dew which condenses naturally in some local areas. An ingenious method of dew collection has been devised by a farmer on the island of Brava in the Cape Verde archipelago. There is little rainfall in the Cape Verde Islands and it never rains during the long dry season. But the land is generally shrouded by heavy mists or fogs and this produces much natural condensation on to the leaves of plants and directly on to the soil. This moisture is often sufficient to carry crops through the dry season. But drinking water is in short supply and the farmer in question had to transport water for some distance.

However, he noticed that dew was condensing so heavily on the leaves of a giant lily that it dripped on to the soil. So he tied the leaves in such a way that the dew dripped from leaf to leaf and down to the ground. He then planted 60 of these lilies in a row down a slope and made a gutter from the highest to the lowest by placing the large boat-shaped leaves of other lily-plants on the ground. At the end of the gutter he constructed a small reservoir, from which he has since collected an average of 200 litres of fresh water daily. When the fog is dense his row of plants collects 600 litres in a day.

PEOPLES OF THE DELTAS
A see-saw battle between river and sea

by Adriaan Volker

THE delta of a river is the last gift to man of the watercourse on its way to the sea The classic example, of course, is Lower Egypt, but the description also applies to many other delta areas which range among the most productive and most densely populated parts of the world.

In the delta the river drops the sediments, silt and sand—the products of erosion—that it has been carrying all along its course from the mountains to the sea or to the lake into which it flows. The slope that provides the driving force for the flow of the water and the sediments flattens out when approaching the coastal area, the river's velocity decreases and to carry the flow from upstream still further, it must split up into a number of branches or distributaries.

At the point where this happens, the apex, the deltaic and final reach of the river begins. In this reach the velocity decreases still further and the flow is finally backed up by the sea water. Unable to carry the sediments any further, the river starts building up land. Thus, as the land area expands at the expense of the sea's domain some of the soil lost by erosion is recovered and restored to man.

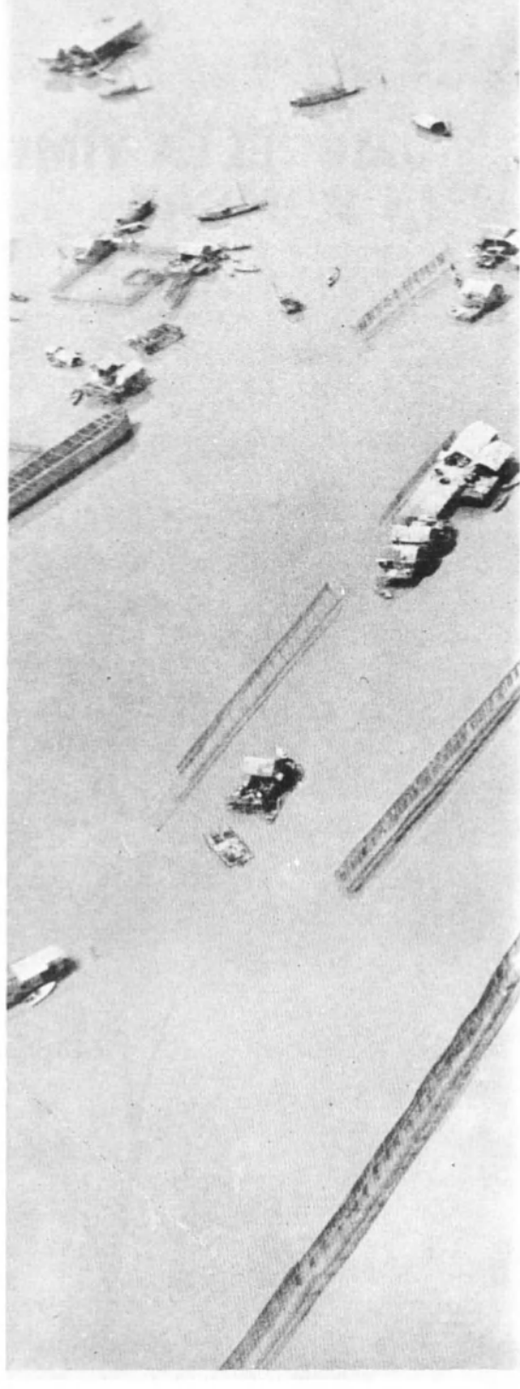
But the sea fights back. Tidal currents and storm surges remove some of the sediments deposited in the delta and carry them to great depths.

A continuous struggle goes on in a delta between the river and the sea, and when Man intervenes to utilize the land, he too must face the destructive power of the tidal waters.

Not all rivers build up deltas on reaching the sea. When the forces of the sea prevail because of strong tides, great depths and the impact of the waves, or when the delta area is rapidly subsiding, a single estuary is formed over which the sea is master. Although favourable conditions for delta formation are found in shallow lakes without tides and waves, the largest deltas have been formed along the coast of oceans, seas and inland seas for it is here that the largest rivers emerge.

When a river reaches its delta the scenery changes, the horizon widens, land and water mingle, the river becomes less turbulent and near the sea it is dominated by the slow breathing rhythm of the tides. The Greek astronomer and geographer, Pytheas, who visited northern Europe in the 4th century B.C., described the delta of the River Rhine as the "Sea-Lung," which he said was "somewhere in the north where ice, water and air mingle—without doubt the end of the earth." And (as a man from the Mediterranean), he was struck by the much greater rise and fall of the North Sea tides.

Even the atmosphere changes in the delta; the light which is filtered and reflected from all sides becomes more diffuse. The special qualities of light found in deltas inspired and influenced the Dutch school of painters.



Monsoon floods invade a Cambodian village whose houses are raised on stilts. The floods, which irrigate the rice fields, are welcomed, for the people have learned to adapt their lives to flood conditions. Farmers become fishermen and everyone travels by boat.

© Rapho
Claude Ghioneaud.

Delta areas are blessed with many natural advantages which encourage man to make use of them. All the water from the river basin reaches the delta situated at its lowest point, and water is therefore relatively abundant. The fine-grained soils are fertile and deep and floods bring a constant supply of new sediments. The high underground-water table provides a natural supply for crops.

Only in arid climates may the underground-water table not be high enough during the whole year. The remedy, irrigation, is relatively easy to apply because of the flatness of the land and its low elevation with respect to river water levels. The dense network of river branches and creeks provides an excellent and safe communication system.

In the early stages of human settlement men made their homes on the natural ridges or levees along the river branches and creeks where the land is higher than in the central part of the delta areas and affords a certain degree of natural protection against floods. In some deltas this stage was followed by the dredging of a network of canals to open up the area. Once again farm houses were built along these new watercourses and thus the characteristic type of settlement in the deltas is one of ribbon development.

Soon the need was felt to control the flood waters from the river. Embankments were thrown up along certain reaches of the river branches, thus providing

partial flood protection and leaving other areas open as ways of escape and release for the highest floods.

To extend the flood protection system, dikes were built encircling the low-lying areas so as to exclude the flood waters completely. As this hampered the natural drainage of excess rainwater, it became necessary to install a drainage system with sluices equipped with movable gates, drainage canals, ditches, etc.

In the deltas in semi-arid zones, irrigation was introduced at an early stage. Classic examples are the delta of the Nile and the internal deltas of the Euphrates and Tigris and the Indus which became sites of early civilizations.

The natural advantages of deltas were recognized in an early stage of history but it was soon realized that to gain the full benefit of these advantages certain technical problems would have to be solved.

First there is the problem of floods. Deltas are invaded by floods from two sides: from the rivers and from the sea. To a certain extent the river floods are beneficial. They supply the land with fresh sediments thereby improving the soil structure and raising the land elevation. The river flood is the main agent in building up the delta. The flooding of the land does not necessarily preclude use of the land for farming. All depends on the nature of the floods, the climate and the adaptability of man "to live with the floods."

The large and densely populated deltas of the River Mekong in Viet-Nam, the River Chao Phya in Thailand and, to a certain extent, the River Irrawaddy in Burma, which are flooded annually, show that the land can be used for agriculture and human settlement.

But two conditions must be met. Firstly, the floods must be gentle ones, i.e. where the water level rises slowly, remains at about its maximum for quite a long period, and then slowly recedes. Secondly, the climate should allow a crop of rice to be raised during the flood season.

Rice is the only profitable crop that can grow in rising water, providing that the rate of rise is small. Rice still grows in water several metres deep and is salt tolerant. Hence it is the most suitable crop for deltas in the humid tropical zone which, lacking flood protection works, are exposed to inundation.

The most interesting example of intensive use being made of a deltaic area which is flooded regularly is the delta of the River Chao Phya. Here a crop of rice is raised during the wet monsoon from May until November. Since rainfall during that period is not usually adequate to meet the crop needs the additional water supply by flooding is an absolute necessity. The gently rising flood waters are beneficial and if they

CONT'D ON NEXT PAGE

HARNESSING THE MEKONG

THE Mekong, seventh longest river in the world, descends from the snows of the High Tibet plateau and flows for 2,500 miles before reaching the South China Sea. During its journey it crosses six countries—Mainland China, Burma, Cambodia, Laos, Thailand and Viet-Nam. A few small dams have been built on its tributaries in Thailand and some channels cut for irrigation, drainage or navigation, but nowhere is the main channel crossed by a bridge; nowhere is it curbed by a dam. Most of the water flows from source to sea without being used by man. Today the Mekong is the scene of a historic international project in river development. Under the auspices of the United Nations, 14 countries have begun to help the peoples of Cambodia, Laos, Thailand and Viet-Nam to make use of the abundant waters of the lower Mekong. Because none of the four countries nor even all of them together have the technical or financial resources for such a huge project, the United Nations helped them to set up a committee to study the Lower Mekong Basin, whose present population of 20 million is expected to double within 25 years. Two major cities of southeast Asia—Saigon-Cholon and Bangkok, each with a population of one million—are outside the basin. Except for the 500,000 people in the Cambodian capital, Phnom Penh, and the 100,000 in the Laotian capital, Vientiane, the population of the basin is largely rural. Rice-growing, the basic activity of the majority, is dependent on the monsoon cycle. The water management plan will make possible flood control and increased irrigation, and thus the cultivation of a second annual rice crop over large areas. A number of dams are planned: in the Pamong gorges, 20 miles from Vientiane; at Khemarat, near the confluence with the River Mune; at the falls of Khone and at Sambor. Finally, a dam built on the Tonle Sap river between Cambodia's Great Lake and the Mekong will increase the lake's capacity as a flood reservoir. The Mekong will become a year-round deep water channel right up to Vientiane—1,000 miles from the sea. Unesco is supervising the preparation of a mathematical model showing the Basin's present hydraulic characteristics and how they will be modified.

Unations

DELTA BASIN *(Cont'd)*

Floods that bring fertility

fail to occur the crop suffers damage by drought. People in the Chao Phya delta have got accustomed to the cycle of the floods and have learned how to live with it.

Things are very different when the floods are of the flash type or when the climate is unsuitable for rice-growing. Flash floods, appearing suddenly and causing rapid variations of the water level, are destructive. In such cases little use can be made of the land areas in the delta unless a system of flood protection works, such as embankments, has been made. Thus in the delta of the Red River in North Viet-Nam, where flash floods occur, dikes have been built to protect the land. This system of flood protection may be more than two thousand years old. However, in the delta of the River Mekong in Viet-Nam, where the flood waters rise and fall slowly, there are no dikes.

Although a good crop of rice can be raised under conditions of natural flooding, the yields remain relatively modest. To obtain the high productivity level of the paddy fields in Japan, China, Spain, and Italy, for example, adequate water control is an absolute necessity, and this naturally entails flood protection, drainage and irrigation.

The menace of floods from the sea is even more serious than that from rivers. During storm surges the sea level may raise several metres above the normal, and if the dikes fail vast areas become deeply inundated with salt water. Sea floods are unpredictable and always destructive. Thousands of casualties were reported during storm surges or typhoons which hit the coastal and deltaic areas of Holland in 1953, Japan in 1959, Germany in 1962 and East Pakistan in 1960 and in 1963. Considerable damage by loss of property, loss of crops and salinization of the soil occurred.

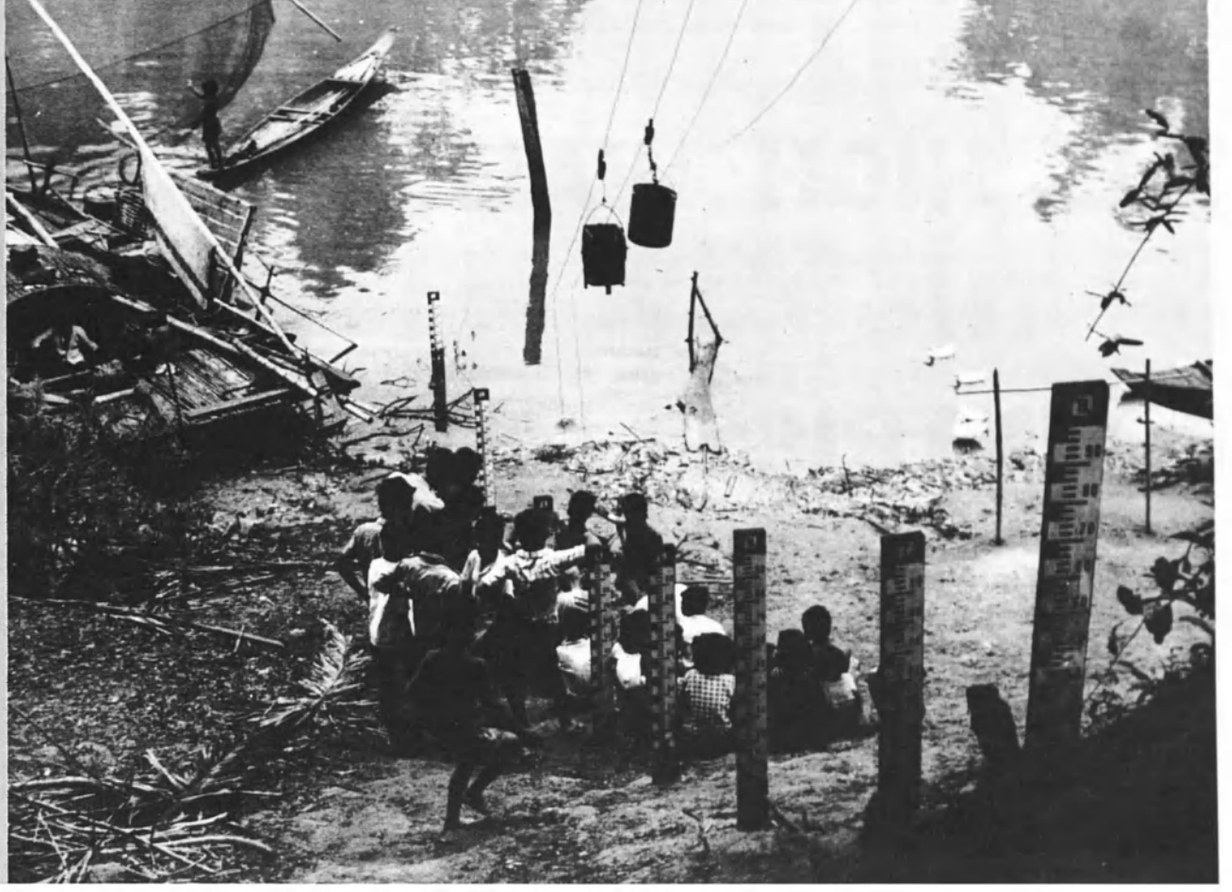
The history of the deltas is marked by a succession of flood disasters. Man however has not abandoned his land but has fought back, strengthening his systems of defence against the possible return of similar or even greater floods. Thus the storm flood disaster of 1953 in the Netherlands led to the execution of the Delta Plan aiming at the enclosure of tidal estuaries of the River Rhine (see page 48). Similar works were carried out in Japan in the area of Nagoya after the 1959 floods.

Not all deltas are exposed to storm surges from the sea. In the deltas of the River Irrawaddy in Burma and the River Chao Phya in Thailand flooding of the coastal strip only occurs during exceptionally high tides and few protective works are needed.

Even if the land is well protected against direct invasion by the sea a secondary problem may arise through the infiltration of salt water into the river branches and the land areas of the delta. The sea water penetrates into the open estuaries and, being heavier than fresh water, it creeps over the bottom of the river in an upstream direction. It mixes to some extent with the fresh water on top, making the river water brackish over a considerable distance from its mouth and thus unsuitable for irrigation or drinking.

This happens especially in the dry season when the river flow which normally halts the saline water is at its weakest. The saline water also enters the subsoil and even at shallow depths the underground water may become quite brackish. This underground water may seep out and ooze to the surface, contaminating water in the ditches and canals. In developed delta areas considerable amounts of salt are admitted when ships coming from the sea enter locks. Another source of salt pollution is the waste water from mining and chemical industries.

Thus the protection of fresh water supplies in the coastal zone of a delta is nowadays a major problem. It is a latent menace, less spectacular but no less serious than the more obvious and direct attacks of the sea. Early settlements in deltas were usually above the limits of the salt water intrusion, but with increasing population pressure and need for more arable land and with the construction of harbours close to the coastline, use has to be made of areas exposed to penetration by salty waters.



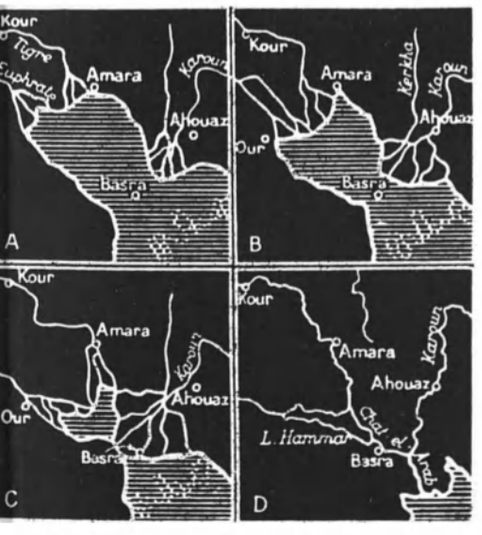
Left, a Cambodian technician using a surveying instrument during preparatory studies for the Lower Mekong River Basin Project. Right, flood level markers on the banks of the Mekong.

Unesco - Mandin

The most drastic and effective measure to halt the salt water invasion is to dam off the estuaries and tidal inlets. In the enclosing dam, sluices with movable gates are provided. These remain closed during high tides and storm surges and are opened to evacuate the flood waters of the river. Projects of this type have been carried out on a large scale in Japan and in the Netherlands. The enclosed water areas of the estuaries turn into fresh water reservoirs, the coastline is shortened, the drainage and irrigation facilities of the adjacent areas are improved, etc.

Thus deltas offer a never-ending challenge to their inhabitants: each interference with the natural process of flooding and sedimentation provokes repercussions leading to further action by man.

Many deltas have undergone considerable development. The most ancient example is that of the River Nile. The deltas of the River Po in Italy, the Red River in northern Viet-Nam and the Yellow River in the mainland of China are other examples of highly productive regions.



From "A History of Land Use in Arid Regions", edited by L. Dudley Stamp and published by Unesco, 1961.

VICTORY FOR THE RIVER

The development of deltas can make striking changes in the outlines on a map. These four drawings show the effects of the progressive silting up of the Persian Gulf by sediments brought down the Tigris and the Euphrates: A. 3000 B.C.; B. 2000 B.C.; C. Roman epoch; D. present day.

The delta areas of many smaller rivers in Japan and the delta area of the River Rhine in the Netherlands have become industrialized areas where the largest ports of the world are found. Other deltas are relatively productive, but still in the first stage of technical development.

Their further development calls for the use of specialist knowledge of problems in the fields of hydraulic and agricultural engineering, soil science, agronomy, coastal engineering, geo-hydrology, etc. The problems of the deltas are of a rather special nature and there are still too few experts in these fields.

The United Nations Economic Commission for Asia and the Far East (ECAFE) at Bangkok took the initiative at a conference in 1960 to promote the technical and economic development of the many large deltas in that region. A general inventory of the area and a survey of the many problems involved were made by a mission of experts from Japan and the Netherlands who had on-the-spot discussions with the local authorities. The results of this study were discussed during a symposium at Bangkok in 1963 which was focused on the "flood control, reclamation, utilization and development" of delta areas in the ECAFE region.

The general scientific aspects of deltas in the humid tropical zone were discussed in a symposium organized by UNESCO in March 1964 and held at Dacca (East Pakistan). This symposium covered a wider field than the ECAFE meeting without entering into the technical questions of engineering and economics which were the main topics of the Bangkok meeting.

Research into the various hydrological problems of delta, estuarine and coastal areas is also one of the items of UNESCO's Hydrological Decade for international collaboration in the field of hydrology.

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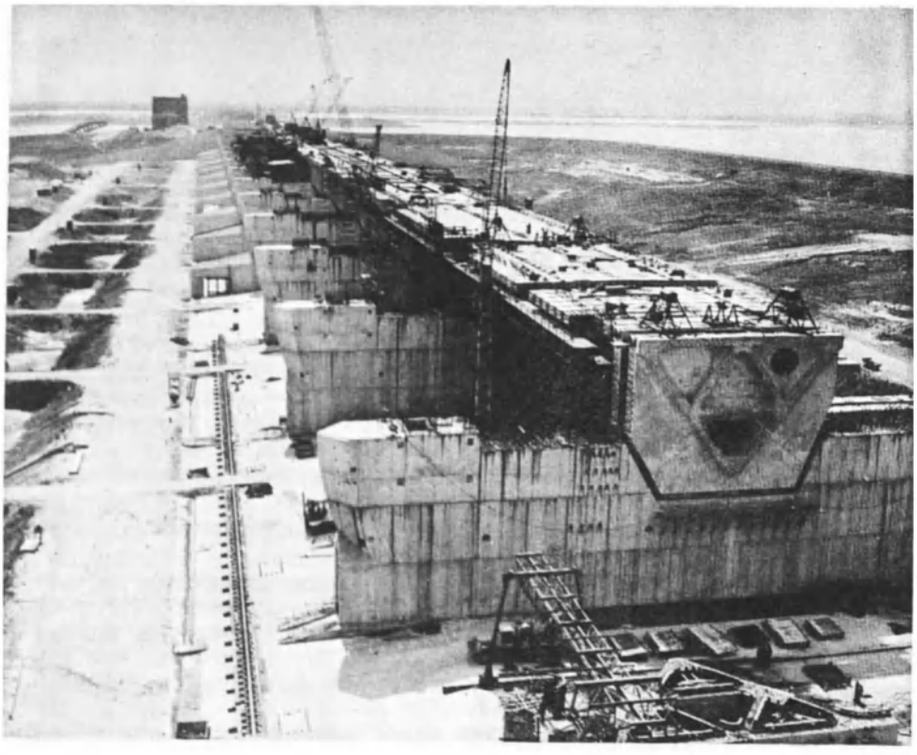
THE HIGH WALL OF THE LOW COUNTRIES

Unesco-A. Tessore



ALL ROUND DEFENCE

The great Haringvliet dam is one of the most remarkable engineering projects ever devised to overcome a double threat from sea and river. It has been provided with 17 large sluices (each 62 yards long) through which excess water and ice from the Meuse and Rhine rivers can be allowed to reach the sea. This group of sluices in the open sea will have an overall length of 1,092 yards (drawing above). Left, the huge sluices during construction. The arms of the dam will reach to the islands of Voorne and Goeree. Roads built along the dam walls will turn them into causeways.

DURING the next 25 years the Netherlands will carry out a gigantic engineering project thanks to the progress of modern technology and the efforts of a people who over the centuries have literally wrested their land from the sea.

The Netherlands is a country that has challenged the sea and won a resounding victory. With much of its territory situated at lower levels than the high tides of the powerful North Sea, the Netherlands has not only defended itself, but has expanded its land area thanks to a remarkable system of pumping stations and coast defences running for over 1,000 miles. For over seven centuries its people have multiplied the sea dikes, greatly reducing the coast line in the north. One simple dike, the Barrier Dam, 20 miles in length, has pushed back the North Sea 50 miles and shortened the coastline by nearly 200 miles. Behind its massive walls, the former Zuyder Zee has become a fresh water lake called the Ijselmeer, and part of it has been drained to give the Netherlands over half a million acres of new land. Other, shorter sea-arms in other coastal areas have also been closed by dikes.

Yet even with all its formidable sea defences the Netherlands suffered a reverse in 1953 when a terrible storm surge of tide and wind broke through several dikes, submerging parts of the islands in the south west.

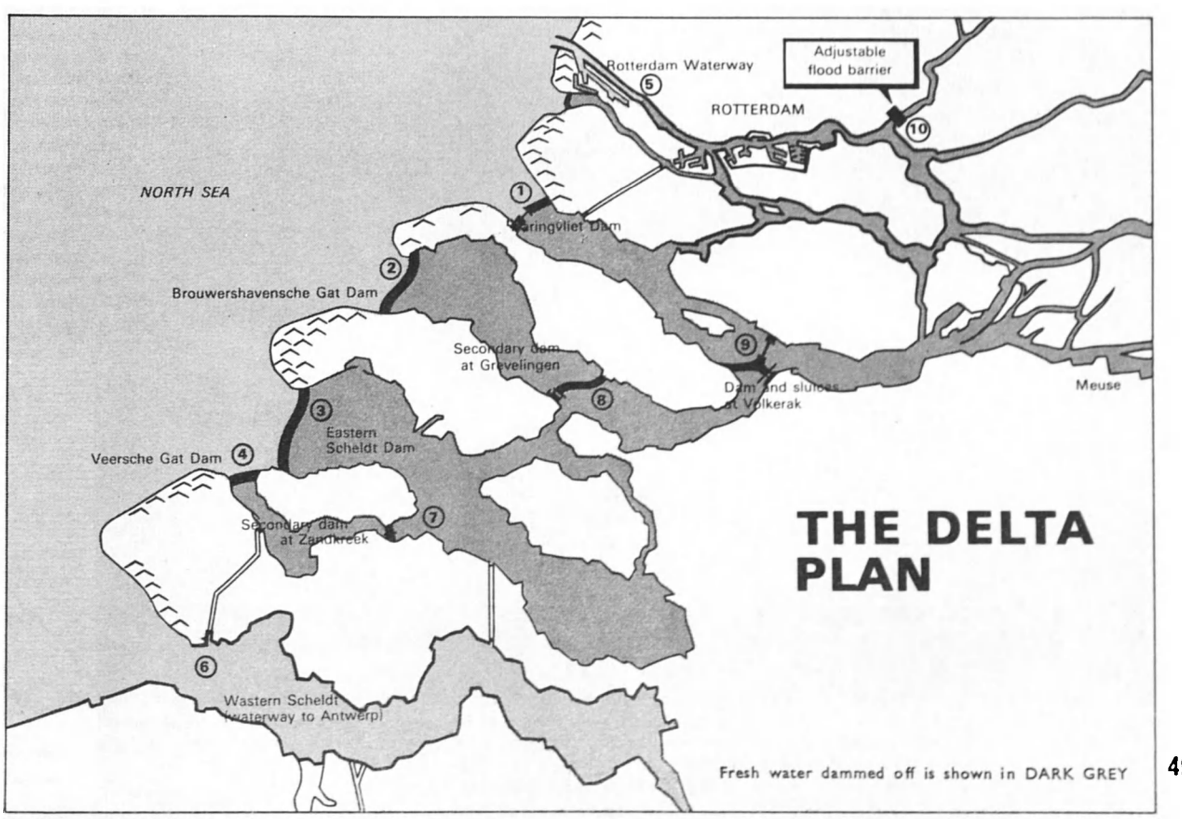
Through the tremendous efforts of its people, the Netherlands filled the breaches and drained out the inundated lands within a year. And within three weeks of the disaster a commission had been set up to study the problem of sea defences and to decide whether to raise existing dikes or to dam off altogether the sea arms in the region known as the Delta Area, where three

CONT'D ON PAGE 51

Netherlands Information Service

GIANT DAMS AGAINST THE SEA

Under the "Delta Project" massive dams will close off four broad deep sea inlets : the Haringvliet (construction dates, from 1957 to 1968) ; the Brouwershavensche Gat (1963-1970) ; the Eastern Scheldt (1964 - 1978) and the Veersche Gat (1957-1962). Secondary dams will be built in the Zandkreek, the Grevelingen and the Volkerak. When the project is finished, the coastline will be shorter by 435 miles and inundation by the sea will no longer threaten the southern Netherlands.



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THREE ISLANDS BECOME ONE

In April 1961 the last of seven great sluice caissons was moved into place to close the gap in the Veersche Gat dam (above). The caissons were left in position to serve as the core of the dyke which has since been completed (left). This dam and a secondary one in the Zandkreek are parts of a single project, the Three-island Project, in which they link the islands of Walcheren North Beveland and South Beveland. By thus completing its arterial network, the Netherlands has given an economic boost to this part of the country.

THE NETHERLANDS WITH NO DIKES...

This drawing shows what the Netherlands would look like if it had no dikes. The dotted line marks the present frontier of conquests over the sea. On these reclaimed lands live two-thirds of the population of the Netherlands. If the inhabitants were to leave their territory to Nature's whims The Hague, Rotterdam and Amsterdam would disappear beneath the sea.

From " Holland Rides the Sea ", by Klaas Graftdik, World's Window Ltd., Baarn

THE HIGH WALL *(Cont'd from page 48)*

rivers—the Rhine, the Meuse and the Scheldt—run into the sea.

Thus was born the Delta Project—a complex of engineering works to give new control over the sea. The work will take 25 years to complete and will bring a physical and economic transformation to a large part of the country.

Under the Delta Project four major sea-arms will be dammed off (see map) and secondary dykes will be constructed. This will give protection against the sea to the entire south west of the country. Two of these sea-arms, the Niewe Westerweg and the Wester Schelde, the approach routes to the ports of Rotterdam and Antwerp, will be left open, but their dykes will be raised and strengthened. To allow the discharge of excess waters or blocks of ice coming down the Meuse and the two lower Rhine arms—the Waal and the Lek—a block of 17 sluices is being built in the dam enclosing the Haringvliet estuary. To make this possible a giant construction pit was made which, when the enclosed waters had been pumped out, formed a man-made island. The 17 sluices built here will have a total length of over half a mile.

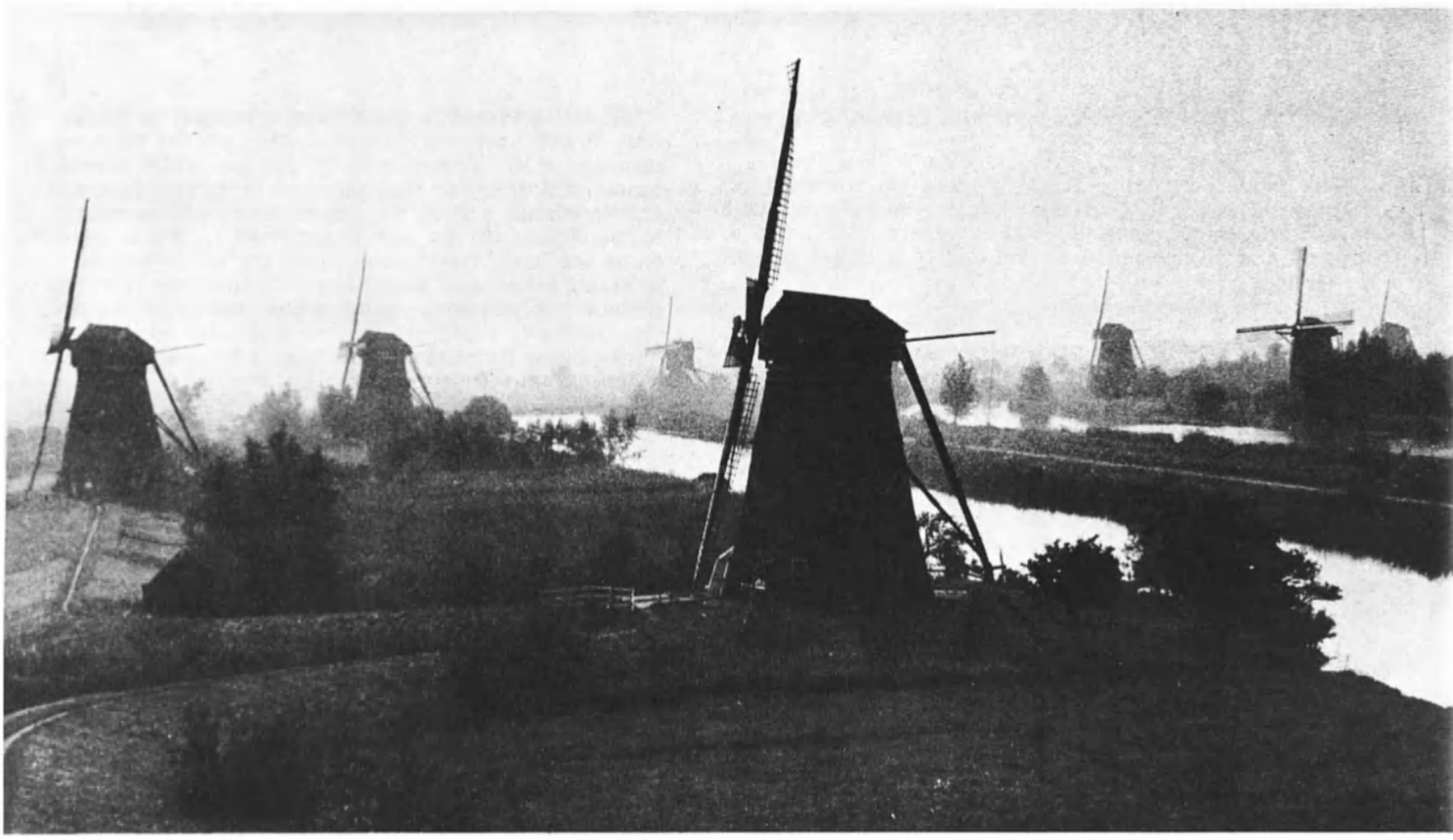
The Delta Project is more than a weapon to defeat the sea. It will have a tremendous effect on the fresh water economy of the Netherlands. Today salt water penetrates canals and drainage channels and infiltrates to the land on the islands and in the coastal areas of the mainland, harming the soil by salt impregnation. When the new dams are built, fresh water from the rivers will be used to desalt canals and land alike. An immense reservoir of fresh water will be built up behind the dams in exactly the same way that the immense Ijselmeer lake was filled by the River Rhine when the Zuyder Zee was closed off.

Three dams will be built on the lower Rhine to allow part of its waters to flow to the Ijselmeer instead of directly to the sea. Similarly, water from the Meuse and the Waal will be diverted via Rotterdam.

The Delta Project will also give an important boost to the Netherlands' economy. An interconnecting system of roads will be built along the dams, linking hitherto isolated islands with the mainland. The broad beaches of Zeeland will also become more accessible. And the vast new expanses of fresh water will become a paradise for devotees of water sports and sailing.

Not all the landscape of the Netherlands has the checkerboard appearance of these fields divided by drainage canals. But if all the country's ditches and canals were laid end to end they would still cover two-thirds the distance to the moon.

© KLM. Aerocarto



POWER FROM

In the Netherlands, the windmill is still a familiar part of the landscape. There are fewer today, of course, than in the 18th century when they numbered some 9,000. But of the 1,750 that still exist, some 1,300 are still doing a job of work—grinding corn, sawing wood, pumping water from the canals. Despite the development of more powerful pumping apparatus many of the windmills are still doing the work they were built for many years ago. Some have been kept in a perfect state of repair for centuries. Symbols of a long history of hard work and ingenuity, the windmills of the Netherlands are classed as historic monuments. There is even a "Windmills Association" whose efforts are deployed to preserve and restore these graceful and picturesque buildings and, when possible, to extend their working life. Left, a windmill at work draining water from a polder—reclaimed land protected by dikes. Above right, adjusting the angle of a windmill sail. On the skill of this man depends the efficiency with which the mechanism will capture power from the winds.

How a series of windmills are used in relays to pump water uphill from one canal to the next until it is high enough to run back to the sea.

THE WIND

Photos © Paul Almasy, Paris

FLOODS !
FLOODS !!
FLOODS !!!

by Maurice Pardé

THE sight of a large river in flood is a memorable experience. As the flow of water suddenly increases, rising by as much as 20 or 30 feet in a few hours, it sweeps all before it, tumbling bridges, uprooting and carrying away trees, tearing down houses and covering the countryside with mud, sand and rocks. This is Nature revealed in a mood of wild rage and devastating power.

Equally impressive, though less savagely spectacular, is the type of flood that sometimes spreads out from the lower reaches of large rivers. Stretching further than the eye can see, the floodwaters are sometimes 30 to 60 miles in width and extend along the river for 300 to 600 miles or more.

Long before men began to spread over the earth, floods ravaged its surface. At the very dawn of history we find man afflicted by them. Stories of flood tragedies, like the epic of Noah and the Ark, are woven into the traditions and folklore of many ancient peoples. And sometimes, traces of the floods recounted in these stories have actually been found by modern archæologists.

Once floods were accepted as accidents—unpredictable and unavoidable. But men have learned more about the part rivers play in the great "hydrologic cycle" and are now using this knowledge to predict floods, in some cases to control the damage done by them and in others to prevent them from happening.

To find the most effective ways of combatting floods, science has set out to learn as much as possible about the major ones: their basic causes, the levels they reach, their maximum discharges, the total volume of water produced and the speeds of their rise and fall. Each river network has its own distinctive features, or perhaps it would be truer to say that many rivers can be placed in distinctive categories. One of the basic aims of Potamology (the scientific study of rivers) is the identification of these "river species."

The River Ardèche, a western tributary of the Rhone River in France, is a typical example of the kind of river where sudden floods occur. The Ardèche quickly swells to its greatest size when it receives between seven and eight inches of rain in a matter of hours from its 730 square miles of catchment upstream from Vallon. Many other Mediterranean rivers in France, Spain and Italy are just as easily aroused and are sometimes equally redoubtable.

In many subtropical and tropical regions the effects of rapid flood rises on the rivers are even more alarming. In such regions great downpours of four to eight inches of rain may fall within an hour over a surface of from 20 to 70 square miles or over an even greater area. River levels rise with terrifying speed; sometimes within hours the flood has reached its peak.

In contrast, on very long and gently sloping rivers like the Mississippi and the lower Yangtse-Kiang, the peak is reached only after the waters have been rising for four or six weeks. They sometimes take even longer to arrive if the floods are caused by successive downpours whose effect is continuous and cumulative.

The amounts of water involved seem slight when calculated in relation to each square mile of the receiving area. But when we look at the gross figures of the volumes of water flowing they are seen to be enormous:—nearly 3,000,000 cubic feet in August 1954 for 540,000 square miles on the Yangtse-Kiang at Hankow; more than 300,000 cubic feet—including the water overflowing the banks—for 1,200,000 square miles on the Mississippi at Vicksburg in May 1917.

The rainfall which causes major floods of this kind covers a huge area—700,000 square miles or more—and is thus well below the average intensity of the downpours on the Ardèche and still less so the deluges of places like Texas, the Philippines or Japan, all of which are confined to small areas. For instance, in 1931, the Yangtse-Kiang above Hankow received about 18 inches of rain, but over a period of two months.

The essential cause of the unprecedented floods on the Volga, 2,400,000 cubic feet in the Kubyshev region for

© Anpfoto, Amsterdam

470,000 square miles, is the melting snow, whose water equivalent, including additional river inflows, totals some 12 inches within a single month. And the giant floods of the Yenesei and the Lena in the U.S.S.R.—possibly totalling respectively 1,040,000 and 960,000 cubic feet—which are the highest in the world after those of the Amazon, are no doubt due to thawing snow which, added to the rainfall, amounts to seven to eight inches in a month, as far as can be estimated.

Floods which are from twenty to a hundred times slower in rising and falling than the ultra-rapid ones nevertheless attain colossal proportions because of the enormous amount of water flowing and the immensity of the area they cover. Between these two extremes nature produces a wide range of floods of intermediate size and varying characteristics.

However, major river floods are not caused exclusively by excessive rainfall or abnormal thaws or a combination of the two. They may also occur without any exceptional increase in water flow when the river bed is blocked, usually for only a period, by obstacles of a solid and bulky kind.

Sometimes the river itself is responsible. Blocks of ice may pile up in narrower or shallower sections of the river channel. Blockages are formed across slow rivers subjected to intense cold, either when the surface is frozen or much more frequently, when the thaw drives the frozen debris downstream.

One example of this kind is the disastrous flood on the Rhine at Coblenz and Cologne in January 1784. In Cologne the levels of the waters were at least 10 feet higher than in any earlier known "iceless" floods. Ice too played a part in the flooding of Budapest when in March 1838 the Danube rose six feet above any previous (or subsequent) recorded level. At the time of the Hungarian catastrophe, a storm wind drove the waters and ice before it and more than half the buildings in Pest were destroyed.

Even higher and more watertight obstacles can be built up in deep and narrow mountain reaches by the arrival of inflowing glaciers.

Spectacular examples occur in the Indus system behind the Himalayas or as it passes through the wild gorges several thousand metres below the peaks. In 1840, a lake 820 feet deep was formed by an obstacle in the Indus at the toe of Nanga Parbat, and one 196 feet deep was created in the Chayog, a tributary of the same river, upstream of the Chang-Kumdan glacier in the Karakoram in 1939.

The worst feature of these obstructions is that sooner or later they break up and waves of swirling and roaring ice and debris plunge into the valleys where they sweep away and crush everything in their path.

Glaciers can also be the cause of other disasters that are not always predictable. In the night of July 12-13, 1892, the Tête Rousse glacier to the south of Mont Blanc suddenly released 7,000,000 cubic feet of water enclosed in a pocket at a height of more than 10,000 feet.

Rushing down the mountain side this mass of water scooped up rocks and earth from the slopes until it increased five-fold, forming a terrifying stream of "lava" —the term used for floods which contain more mud, sand, pebbles and rock than water. There were 175 victims, most of them in the little town of Saint-Gervais.

Flood disasters occur above all where river-beds have been made too narrow by Nature or have been restricted by man-made works, or where the slope is too small to carry away the high discharges that can occur on these rivers. In Canada, for example the memorable April-May 1950 flood on the North Red River coming from the United States caused unbelievable damage in Winnipeg and nearby, despite the fact that its discharge at the time was not considered dangerous by specialists.

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The river mouth wandered 300 miles

As on many other sites, the riverside populations had increased the already dangerous narrowness of the river by constructing far too many buildings, including many factories and warehouses, in the flood plain.

Yet even allowing for the results of man's thoughtlessness and rashness in siting homes in valleys subject to flooding, it is clear that material damage is in fact directly proportional to the power and the nature of the floods in any given river sector.

In the tragic disaster of the Riera de las Arenas and of other small and very steep Catalan rivers in the hilly country behind Barcelona at Tarrasa, Rubu, Sabadell, and other villages, there were a number of causes for the flood which killed more than 700 people in the night of September 25-26 1962.

Firstly, furious discharges of water, occuring in an area of a few dozen square miles, were produced by storm rainfall of short but crushing intensity—more than four inches in three-quarters of an hour. A second reason was the irregularity of the river beds, whose width and depth were far too small to contain the discharges. The crowning misfortune was lack of foresight in choosing locations for residential and industrial buildings. At places where the bridges were too small and too low, wreckage piled up before "exploding" and sweeping all before it. Buildings were shattered and carried away. The roaring masses of water unleashed in these Catalan streams were as deadly as the torrential "lava" already described.

WATER SNAKE. This striking air view of the Kentucky River, a tributary of the Ohio River in the United States, was taken as raging floods swept through the towns of Hazard (top) and Lothair (bottom) last year. Some 25,000 people were forced to flee their homes.

Photo © Associated Press

Rivers of all sizes draining vast, subarid regions, which are virtually unprotected against erosive runoff by their scant vegetation, may increase their volume by 20% to 30% or more through the addition of mud.

Towards its entry into the vast deltaic plain, the Yellow River, the Hwang Ho, has been known to carry down more than 500 kgs. of sediment per cubic metre of water, in spite of its relatively gentle slope. Although these minute particles do not slow down the discharge as would bulkier fragments, the river-bed still cannot contain the water during heavy floods. The water level is swiftly raised by the dropping of the extra solid load—especially of fine sand—and the river flows over what is actually a flat yet still protruding embankment covering an area of more than 58,000 square miles.

When the river has broken through one of its dykes, its murky waters engulf the land and in some places leave layers of mud, several yards thick, around the surviving houses. The waters are unable to return to their former course and several times have flowed to the sea on first one and then the other side of the Shantung Peninsula, 250 to 300 miles from their former mouth.

On September 29, 1887, the Hwang Ho flood waters rushed through a breach in the southern dyke upstream of Kaifeng. Within a few days they had reached the Hwai, itself a dangerous river, and then flowed on to the Yangtse-Kiang. A million Chinese are said to have perished during this catastrophe.

On the Yangtse-Kiang, floods can threaten as many as 25 to 30 million people. An international enquiry showed that in the floods of July and August 1931, some 140,000 people were drowned or were crushed beneath the wreckage of their homes. Many more died of pneumonia, typhoid or hunger.

On the North American continent, and in past times (in 1882, for example), the inadequately banked and dammed Mississippi invaded vast areas, but they were then far less populated. In April and May 1927, when the Mississippi transformed 35,000 square miles into a sea of muddy water, there were 214 victims.

The Ohio is another U.S. river subject to major floods. Its swollen waters are often partially or even entirely responsible for the great Mississippi floods. In February 1937, it surpassed its previous highest level by nine feet at Cincinnati and by ten feet at Louisville. In March 1936, the disastrous flood on the upper Ohio alone rose above the highest flood level ever recorded by nearly five feet at Pittsburgh, where 110,000 people were left homeless and some forty lost their lives.

Another memorable U.S. flood, but this time further West, devastated the Kansas River valley and the valleys of the neighbouring Neosho and Osage rivers in July 1951, yet caused only 19 deaths. Records show that a previous but smaller flood in this area in May-June 1903 claimed over 100 victims. The low casualty list in the recent flood points to remarkable progress made in flood warning and rescue arrangements.

Another U.S. flood, almost as disastrous, occurred in New England in August 1955. Violent currents, flowing down steeper slopes than those in Kansas, made these waters even more sudden and violently erosive. Fed by the torrential rainfall from cyclone Diana, and following a super saturation of the ground by cyclone Connie a few days earlier, the flood raised the River Delaware to greater heights than anyone could recall. But even more astounding and terrifying were the increases on modest coastal rivers like the Naugatuck and the Quinebaug, or small rivers like the Farmington and Westfield which run into the Connecticut. Almost 180 people died in this flood.

Floods that produce sudden and far more overwhelming discharges of water during cloudbursts can make a host

of streams in at least one half of the United States irresistible and devastating.

Of the ultra-rapid type of flood in France, those in the Cévennes, Languedoc and Roussillon, although nothing like as powerful as the Texan floods, often have disastrous results.

On September 22, 1890, some 40 people were drowned by the Ardèche and its tributaries. Nearly 70 years later, on September 30, 1958, the Ardèche flood was less terrible, but the Gardon and the Cèze, which always rise at the same time, reached record heights and claimed 36 victims.

Other floods which France experiences are less swift but even more striking because of the size of the area inundated, the rivers responsible being very large ones. Two notable floods of this kind occurred between June 23-25, 1875 and March 3-6, 1930 in the basin of the River Garonne.

The first, in which quite exceptional floods swept down the Pyrenean rivers, the Ariège and the upper Garonne, caused an unprecedented disaster. Five hundred people perished, including more than 200 in Toulouse. The water was 10 to 15 feet deep in the streets of Agen.

In March 1930, flood levels once again rose almost as high in Agen. This time the water came not from the upper Garonne, but from the Tarn, the Aveyron and the Agout whose maximum flows were perhaps such as occur only once in a thousand years. There were 200 deaths, including 120 at Moissac.

In May and June 1856, flood water swept over the smiling and fertile Loire Valley from the Bec d'Allier down to Nantes at the river's mouth as the dykes gave way in 160 places. Water covered more than 400 square miles.

For many centuries, man has endeavoured to protect towns and rich and populated valleys by building earth dikes along one or both banks of rivers.

An area of 20,000 square miles of land towards the mouth of the Mississippi and its tributaries, are safeguarded in this way against flood risks by 2,800 miles of dikes.

However, by their very success in preventing flooding these river bank defences concentrate the water in a confined channel and thus greatly increase the speed of the floods and hence their maximum discharge capacity. On the lower Mississippi at its confluence with the Ohio River, the progress made between 1882 and 1937 in extending and improving dikes has also raised the heaviest river discharges by from six to ten feet. The smaller number of dike failures all along the River Po in Italy almost

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Photo Cuban Delegation to Unesco

Early in October 1963, eastern Cuba was ravaged by catastrophic floods. Swollen by rains from a cyclone, the rivers Contramaestre and Cauto and several tributaries overflowed their banks. Hundreds of square miles of land disappeared under the waters. Over 1,000 people were drowned and thousands lost all their possessions. Above, salvaging a stranded bus.

FLOODS *(Cont'd)*

Curbing an angry torrent

throughout the past century have similarly been offset by an obvious rise in the water level—three feet or more in certain sections where the bed had not been deepened at all.

This has led to the extra expense of raising the crest and thickening out the body of the dikes to enable them to hold in the higher water levels that they have themselves made more dangerous. Then, on short stretches which have to be safeguarded at all costs, the earth embankments are replaced by narrow verticle concrete floodwalls.

In very critical situations, dikes are gradually raised with sacks of sand and cement to form a makeshift barrier which prevents them from being overtopped and thus inevitably destroyed. In August 1954, during one of the greatest of all floods on the Yangtse-Kiang, as many as 280,000 workers at a time laboured for weeks, progressively raising the crest of the dikes for a distance of 85 miles. Their efforts saved three large towns—Hankow, Wuchang and Hanyang—from inundation.

INSTEAD of raising the banks with dikes, it is sometimes considered more advisable to deepen the bed by dredging. However, it has often been found that the level and surface relief of the bottom conforms to a certain natural balance governed by the slopes and the solid and liquid discharges of the river. Thus, even after dredging the waterway eventually restores the former levels by depositing gravel or sand.

In other cases, one or several river bends are lopped off by digging a straight channel which soon takes all the flow. Shortening the course increases the slope, often sufficiently for the accelerated current to carve out a deeper bed at the bottom. This lowers the flood levels. as it did on the Mississippi where, after 13 bends had been cut off the drop was from five to ten feet between the confluences with the Arkansas River and the Red River.

When topographical conditions allow and relatively limited damage is likely to be caused to existing property, new beds, by-passes or diversions can be made to switch excessive surplus discharges away from areas to be protected. For example, the Sutter by-pass on one side of the city of Sacramento in the United States, and the Yolo by-pass on the other, are used during flood level conditions to relieve the normal bed which passes through the city. Again, upstream of New Orleans, the Bonnet Carré floodway on the right bank of the Mississippi diverts substantial discharges—nearly 200,000 cubic feet in 1937—towards Lake Pontchartrain and the sea.

Another flood antidote which has captured popular imagination is re-afforestation. However, certain aspects of its effects are still not sufficiently well-known, and in the main, the results so far obtained have been irregular and somewhat unpredictable.

In one important respect, the function of re-afforestation cannot be questioned. A good forest overburden will always reduce erosion and hence the carrying away of solid matter. This helps to prevent the possible silting up of reservoirs and above all the silting of river beds and the rise in their level following floods. However the quantitative effects of re-afforestation differ immensely from one basin to another, depending on the interplay of the different factors involved.

In the vast majority of small basins and in almost every situation, the effect of re-afforestation is favourable, not so much on the total flood volume but on the maximum discharges of water. Woodland has several properties which tend to reduce these discharges: the interception of the water by branches and especially by leaves and needles, the usual permeability of the soil, disturbed and worked over by the roots, the curbing of runoff by undergrowth or by wood debris.

Woodland is sometimes completely successful in preventing rivers from becoming swollen. However its properties are obviously most effective when dealing with moderate downpours, when temperatures are high and

after long periods without rain. Against heavy rain falling on vegetation and ground that has already been soaked a forest is virtually ineffective.

Even when the full impact of afforestation on floods is known, it should be remembered that these effects are more or less proportional to the percentage of wooded area in a particular basin. Many people, tend to forget that increasing the wood area from 10 to 20% or even in certain cases 50% will hardly alter the flood situation. And in most heavily populated and modern countries, the practical possibilities for retimbering are no greater than these.

A sure remedy, for floods, provided it can be applied, is to build dams big enough to intercept the dangerous discharges for as many hours or days as may be needed. This is the water which, if it were to flow off naturally beyond the reservoirs, would flood the places in need of protection.

The Chinese have recently completed dams which promise to tame the floods of the Hwai River. They have built an even more elaborate structure across the Yellow River at Sanmen, in a rocky narrows not far from the entry to the delta plain. The dam is 300 feet high with a storage capacity of 2,275,000,000,000 cubic feet. The most formidable maximum discharge that could be expected will be reduced to a fifth by the reservoir.

In Texas, the Travis reservoir on the Colorado River can cope with 84,000 million cubic feet of water which is more than the total volume of the worst sudden but brief floods which are let loose in this river basin.

DOZENS and even hundreds of other examples could be given of isolated or interrelated reservoirs now in service which are designed to reduce the maximum flood discharges either permanently or in emergencies. Many such reservoirs exist in the Massif Central, in France, in the Harz Mountains and the high-lying areas of the Rhineland in the Federal Republic of Germany and in the mountains of Bohemia. There are many more in Japan and in the United States. In the Tennessee valley network, for example, there are 27 dams storing as much as 945,000 million cubic feet of water. And on the middle Missouri, three dams alone —Fort Peck, Oahe and Garrison—would be capable of stopping, if necessary, more than 2,800,000,000,000 cubic feet which is more than the total annual discharge of the river.

On many rivers quite excellent results are obtained by combining several methods: reservoirs, dikes, improved bed-lines, removal of bends, diversions and so on. In addition roads and railway tracks are moved away from river courses and raised on embankments.

When a project for any river basin is drawn up, the hydrologist first has to calculate the maximum discharges that are likely to occur, the total volumes of water that may flow and the duration of the longest anticipated floods. He is, in fact, trying to determine the characteristics of floods that are only likely to occur once every 100, 500, 1,000 or even 5,000 years or more.

Probability computations are used for drawing up these forecasts based on all the past river and rainfall data recorded in the basin.

Much shorter-term forecasts with precise data are needed by people living close to rivers that have not been effectively protected against flooding. The inhabitants must be given enough time to remove themselves and their possessions to safety. The ability to produce these forecasts depends on various factors: the anticipated time-lapse between the flood warning and the arrival of the flood waters; and whether the floods are caused by rainfall or snow or to something happening on the river itself.

In the present state of scientific knowledge, it is impossible to predict with certainty several months or weeks in advance that there will be a rainstorm on a given day or even within a given week.

However, reasonably accurate predictions are often made 24 or 36 hours in advance as to whether a rainstorm of a certain intensity will fall on a given basin or not. But in general, it is not possible to say with great precision how long the rainfall will last or what its total volume and varying intensities will be.

The element of doubt in working out temperatures is much smaller and thus it is easier to know how much snow will melt on the next day and the following one.

When a rainstorm has already produced flows of water that are liable to swell the rivers, an efficient communications system enables a good tentative assessment to be made of likely flood levels.

The most reliable short-term forecasts are above all hydrometrical. They are based on accurate information from stations upstream where the discharges or levels have been sucessively recorded.

In basins where extensive experience of observations has removed some uncertainty factors effective and even remarkably forecasts can be made, as in the case of the very heavy floods on the middle and lower Mississippi, where peaks of 40 to 60 feet can be predicted to within about four inches a fortnight or a month ahead.

However, for places that are invaded and devastated by floods within an hour or so after the end of torrential downpours of the type that occur in Texas or even in the Cévennes, it will still be very difficult and sometimes impossible to give warning in time in spite of improved telecommunications.

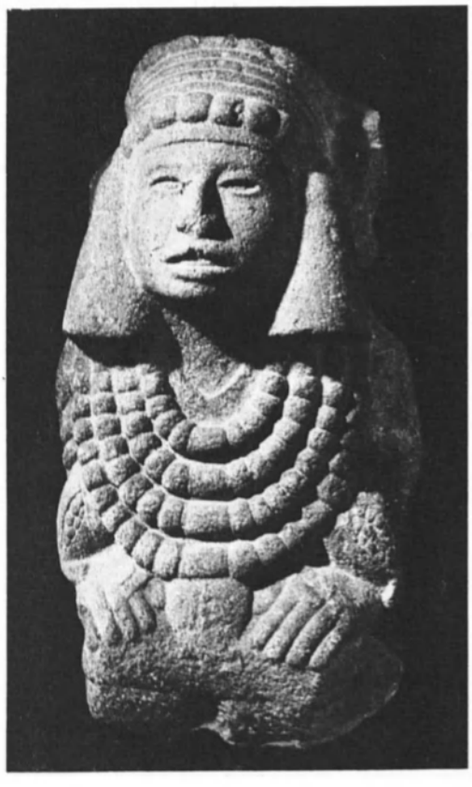
MAURICE PARDE *is professor of physical geography and river hydrology at the University of Grenoble, France. His many works on hydrology include "Fleuves et Rivières" (Rivers and Streams) published by Armand Colin, Paris, 1947 and "Potamologie" (Potamology) published by the University of Grenoble in two volumes, 1954.*

THE DELUGE. An 11th century mural painting in the church or St. Savin-sur-Gartempe, France, depicts Noah's Ark afloat on the waters of the Flood. This deluge is described in the Bible, which relates that the the rain "was upon the earth for forty days and forty nights", and the story is also told in some texts written in cuneiform. Tales of great floods are woven into the traditions and legends of many ancient peoples. Sometimes traces of such floods have been found by archæologists.

Archives Photographiques, Paris

HYDRAULIC CIVILIZATIONS

by
Pedro Armillas



GODDESS OF THE WATERS. This kneeling statue is Chalchiuhtlicue, Aztec goddess of the waters, and a feminine counterpart of Tlaloc, god of the rains. She wears a breast-plate composed of four rows of green stones and a head-dress of sea shells—symbols of water.

THE oldest civilizations of the world—ancient Egyptian, Sumerian, and Harappan—arose on arid lands made productive by great rivers whose floods moistened the parched ground and enriched the soil with deposits of silt; these centres of higher culture were situated in the Nile River valley, the alluvial lands between the lower courses of the Euphrates and the Tigris, and the area watered by the Indus River and its tributaries in Punjab and Sind.

Other old, independent growths of civilization took place either in desert zones—where conditions made the collection of underground moisture or irrigation by diversion of surface streams a prerequisite for agriculture—or in areas where the vagaries of rainfall—extreme variability from year to year, frequent droughts or delays in the start of the rainy season—brought the threat of crop failure and consequent disaster to the people.

An example of the first of these cases is the ancient Peruvian civilization which, long before the Incas, attained its zenith on the riverine oases scattered along the Pacific coast; the second conditions prevail over most of China, and especially in the Huangho basin where Chinese civilization first blossomed, and also over the central Mexican Plateau which was the homeland of a civilization already old when the Aztecs arose to imperial power.

The evolution of civilization is marked by profound changes in economic relations and the structure of society, which in their turn have created new forms of political organization.

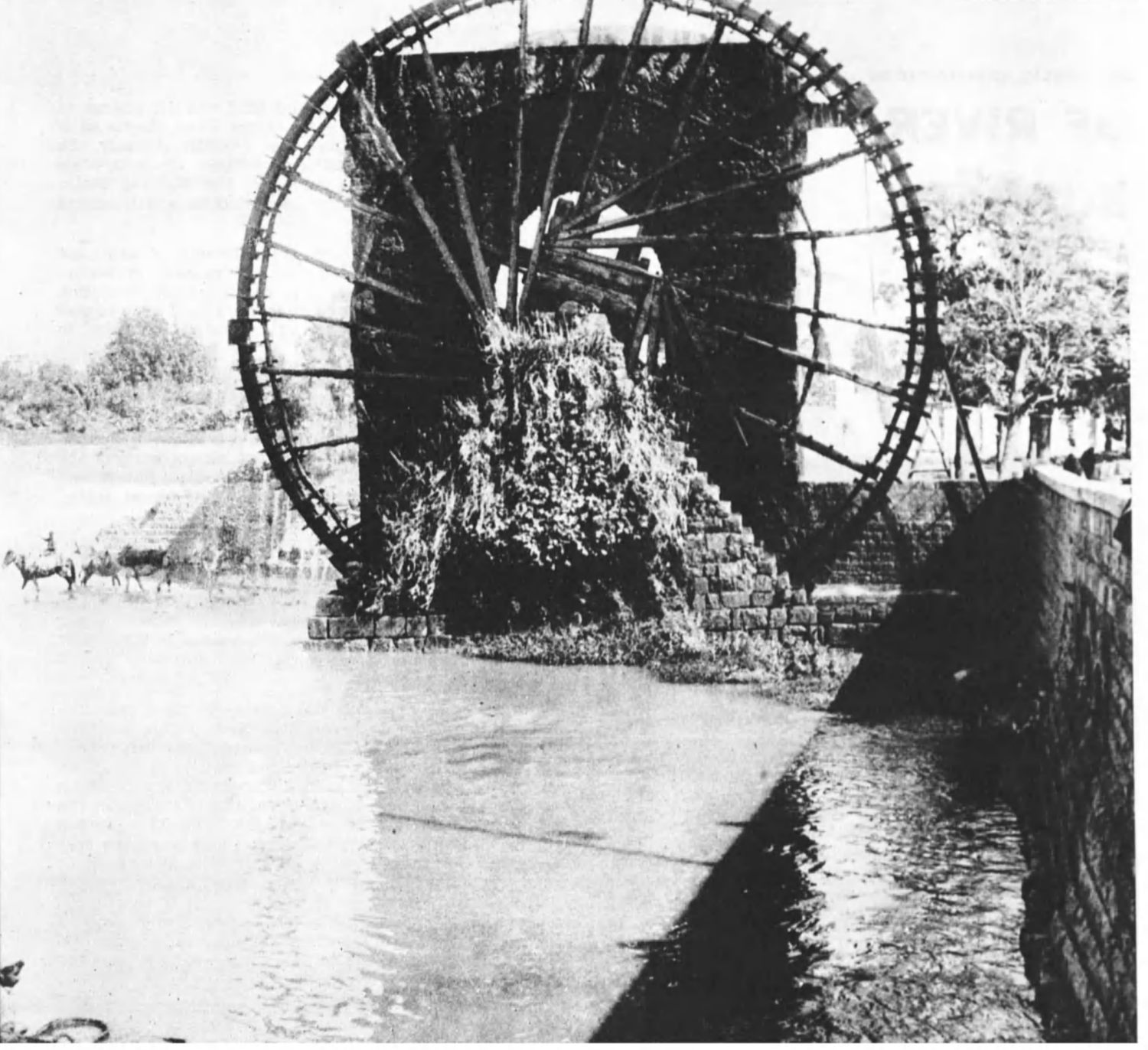
Our knowledge of the early stages of development of the ancient civilizations is admittedly very sketchy. Recorded history—the keeping of annals and writing of chronicles—is one of the consequences of the expansion of intellectual horizons that goes hand-in-hand with the birth of civilization. Thus, the beginnings of the social processes that led to the transformation can only be dimly perceived in the twilight of the past or else must be inferred from archæological discoveries.

NEVERTHELESS, in the examples we are concerned with here, in some cases these social processes certainly were, and in others, may well have been, closely linked with the wide-scale use of labour for land improvement (land reclamation and soil conservation) and increased food-production through intensive cultivation. Any doubts about this are due to lack of knowledge concerning the early stages of civilization in the Indus River Valley and in central Mexico.

In arid lands or in areas afflicted by recurrent droughts or subject to catastrophic floods by the same rivers that brought them life, people were forced to undertake two kinds of water-works: productive (reservoirs, irrigation canals) and protective (dikes). They did so to produce sufficient food for large and stable populations, to obtain the surpluses needed to support the superstructure of civilization, and also to avert the calamity of a total loss of harvests.

Potentially fertile but swampy alluvial lands were also reclaimed by means of drainage ditches or artificial gardens floating on shallow waters (*chinampas* in the lakes of central Mexico and gardens of the same type in the Vale of Kashmir). All this has been done since remote times to enlarge the areas available for farming.

Although small-scale irrigation does not necessarily produce radical changes in farming communities—as evidenced, for example, by the



EARLIEST WATER WHEEL. A "noria" on the River Orentes in Syria, a rare existing example of the earliest machines used to draw power from the waters of rivers. It carries water to an aqueduct built by the Romans to irrigate nearby fields.

Photos © Musée de l'Homme, Paris

archæological record on irrigation and society among the prehistoric Hohokam people of southern Arizona (although here the failure to grow can be explained by the very limited water supply)—it certainly has potential effects on social and political development.

Firstly, it creates landholdings with different levels of productivity, and thus tends to promote private ownership of improved land and the accumulation of wealth. Secondly, when a number of communities become dependent on the flow of the same stream, intercommunal competition eventually requires the establishment of supra-communal authority to allocate water-rights and to mediate in conflicts.

An agricultural economy depending on small irrigation works may lead to the establishment of feudal societies, as happened in China during the Chou Dynasty (from 1100 to 250 B.C.) or in ancient Japan.

Large scale water-works, on the other hand, require mass-mobilization of the labour force; hence, such projects presuppose the existence of a political machine with power to demand service from the people.

The building of extensive canal networks in ancient Sumer (southern Mesopotamia) certainly post-dates the establishment of dynastic states and may well have taken place no earlier than the rise of empires. There is no available evidence that state hydraulic enterprises existed in Pharaonic Egypt during the Old Kingdom

CONT'D ON NEXT PAGE

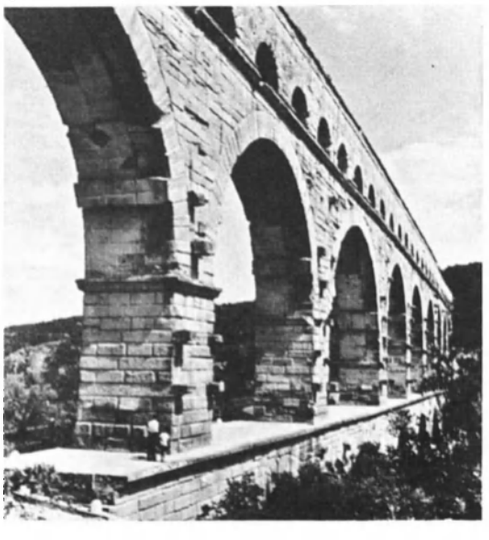
OF RIVER BONDAGE

© Pierre Verger

INCA WATER-WORKS. In the steep valleys near the ancient Inca capital at Cuzco, in Peru, many sections of massive aqueducts, 50 to 70 feet high, still exist. The Incas built them to carry away water from a network of drainage canals, often hundreds of miles long, in a region where it rains heavily for half the year.

ROMAN AQUEDUCT. No fewer than 30 cities of Roman Gaul were supplied by aqueducts. The most massive of all, (below) which carried water to Nimes, still stands astride the River Gard, a tributary of the Rhone, in southern France. It was built in 20 B.C. (the time of Augustus Caesar). It is 880 feet long and rises 157 feet above the valley.

© Paul Almasy, Paris



period; the first recorded undertaking of this kind was the linkage of the Nile to the Fayum depression, so as to use Lake Moeris as a reservoir to regulate the floods, under the Twelfth Dynasty. In ancient China, historians agree that construction of large-scale water-works did not begin until the Period of the Warring States (481-255 B.C.), when Chinese civilization was already one thousand years old.

To understand the processes involved in the growth of hydraulic societies it is worthwhile to note that the development of water-control in China at that time is linked to the technical revolution brought about by the appearance of iron tools, the use of oxen to pull the plough, and the increasing practice of manuring the fields to sustain fertility.

The greater productivity of agricultural labour led to the disintegration of the feudal system and stimulated the growth of private land ownership; the breakdown of feudal bonds left a mass of former peasant-serfs liable to be drafted for the construction of public works. At the end of this period of development, the opening of the Chengkuo Canal in 246 B.C. brought prosperity to central Shensi and gave the King of Ch'in power to subjugate the rival feudal states, thus achieving imperial unification of the country.

GOVERNMENT management of large scale water-works led to the development of a bureaucracy and the dependence of the subject classes upon it. The term "hydraulic civilizations" refers specifically to those states whose social structures were shaped by these forces.

The increase of water-control and the development of hydraulic societies appear to be reciprocal processes and the fact has long been recognized. The connexion between farmers' dependence on water-works and the structure of society was remarked on by Pedro de Cieza de Leon, one of the Spanish conquistadores of the northern Andean region of South America. Cieza noted the contrast, on the one hand, between the submissiveness of the civilized Peruvian Indians, long used to obeying masters and paying taxes, and the easy downfall of the powerful Inca Empire and on the other, the rebellious character of the uncivilized tribes of Colombia who long resisted colonization. The reason for this, writes Cieza in his description of these peoples (first printed at Seville in 1553) is that the Colombian tribes never had centralized political organization, were unused to servitude and depended on rainfarming. When harried by the Spaniards, they easily escaped to the bush where new clearings allowed them to raise their crops and live free from outside interference.

On the desert Peruvian coast, the chronicler continues, men were bound by nature to the riverine oases, and agriculture depended on the state-controlled irrigation systems. Restrictive geographical conditions also prevailed in the Andean highlands, where the crops grown on terraced mountainsides relied on water conveyed by elaborate systems of aqueducts; hence, the Indians could not rebel without risking their means of livelihood.

Another example is ancient China where public hydraulic enterprises undertaken at the closing of the feudal era played a paramount role in creating economic bases for political domination. These in turn led to imperial unification. Chinese historians of the ensuing period (Han dynasty) were thus well aware of the relationships between state-power and water-control. Some perceptive observations on this subject are found in the *Book of the Earlier Han (Ch'ien-han Shu)* which was given its final form by the Chinese historian, Pan Ku, who lived from 32 A.D. to 92 A.D.

Modern theoretical analysis of hydraulic civilizations owes its beginning to students of society and culture, and since the early 1930's, some distinguished researchers have produced studies analyzing the structure of these communities, describing the processes of their development, and explaining their role in social evolution.

PEDRO ARMILLAS, *Mexican historian, archæologist and ethnologist, is a leading specialist in the pre-Columbian history of the Americas. He is now working for the Anthropological Museum of Michigan, U.S.A., for whom he has carried out numerous archæological excavations in Guatemala, Honduras and El Salvador.*

© Paul Almasy, Paris

Like an ancient frieze brought to life, a camel train crosses the River Zayendeh at Shahristan, near Ispahan, in Iran. This striking brick and stone bridge dates from the 11th century, Mohammedan era (17th cent. A. D.).

Letters to the Editor

COLOUR FOR THE UNESCO COURIER

Sir,

Congratulations on your excellent issue of May 1964 with its articles on juvenile delinquency and on Galileo. I hope that the lives and work of other great men will be given an equally fine presentation in future numbers.

There is something else I have been thinking about for some time. You have covered subjects such as the stained glass of Rheims cathedral and the art treasures of Nubia in past issues as well as astronomy in your May issue. I feel sure that all these first-rate numbers would have been greatly enriched by the inclusion of a full colour plate.

In view of your large circulation I am sure that the cost of such an innovation would not call for a very large increase in your subscription rate. Many people, like myself, would welcome this added feature. THE UNESCO COURIER, a magazine of world standing, would be even more appreciated and treasured by its readers.

Georges Forcinal
Bron, France

Ed. Note: The Unesco Courier will introduce full colour pages on a regular basis with the January 1965 issue. See announcement back cover.

CHINESE CALLIGRAPHY

Sir,

I greatly enjoyed your issue on "The Art of Writing" (March 1964). However, I feel that such a vast subject deserved an additional half-page or so devoted to bibliographical sources. Do you know of any works dealing especially with Chinese and Japanese ideograms and Chinese, Japanese and Arabic calligraphy and particularly from an aesthetic point of view? I have already read Etiemble's book, "Writing", published by Editions Delpierre, Paris.

Paul Robert
Sceaux, France

Ed. Note : The general bibliography published in our March issue listed several works of interest to the general reader. These, in turn, furnished a much more comprehensive and varied bibliography on the subject of writing. For Chinese writing we recommend "Chinese Calligraphy" by Chiang Yee, published by Methuen and Co., London. There are many other books on these subjets, but most of them have been published in China or Japan and are in the languages of these countries.

CALLING ALL SCHOOLS

Sir,

I am one of a small group of teachers in Liège who have been carrying out a programme of their own creation for the past year. Though in no way inspired by official directives, it is none the less closely and vitally linked with our vocation as teachers. Broadly its purpose could be summed up as "fellowship with all men". Each month we choose a subject from the pages of THE UNESCO COURIER to introduce in our classes. Several of these themes—racism, hunger in the world, the Universal Declaration of Human Rights—have been of the greatest value to the children we teach.

This year we are concentrating on another aspect: international correspondence between schools. We wish to make contact with a network or correspondents from schools in all parts of the world. Can you help us ? We can cover postage costs from the resources of our school co-operative and take care of the problem of translations—at least in three main languages of world communication: English, Spanish and German. Our children are aged from 11 to 14 and all come from working class homes. Our address is 44 Avenue Reine Elizabeth, Liège, Belgium.

Francis de Bruyn
Liege, Belgium

WHEN SPORT GETS OF FOCUS

Sir,

M. Maheu's timely address "Sport is Education" has created a great deal of interest in New Zealand. Apparently, only extracts of it appeared in THE UNESCO COURIER (Jan. 1964) and in commenting on parts of it, one runs the risk of quoting out of context. However, the topic is of such importance that the risk must be taken.

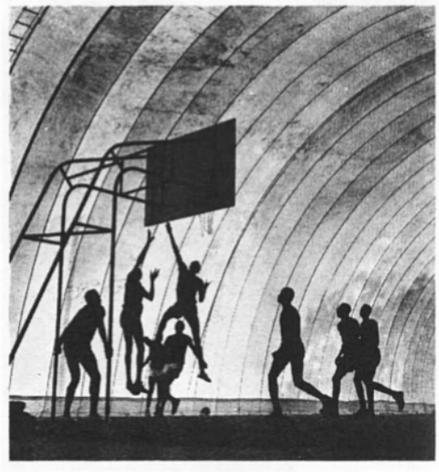
Most people will agree that Pierre de Coubertin went too far in claiming that the modern Olympics should be considered a religion. Fortunately, this has not happened yet at Olympic level, but in some countries, enthusiasm for certain sports bears the hallmarks of religious fervour. Often, the hold on the human personality is such that one particular game, and the competition that supports it, is almost the sole topic of conversation all year round. This commitment to a sport is very close to fanaticism. Once having, as it were, stepped on the sports' stage, some people are psychologically incapable of stepping off it again. Surely this is sport out of focus?

Sport is important, and has been so since homo sapiens freed himself from the burden of unremitting toil. The individual's biological need for physical activity must be met, and sport is a superlative way of doing this. Nevertheless, it is not as important as feeding hungry people, promoting better human relationships, eliminating war, curing cancer or any one of a hundred other pressing human needs. Too often, it seems, skill and success in sport are elevated above attitudes. To me the latter include not only the conventional postures about sportsmanship, but also a true evaluation of sport as play and recreation—something apart, bound by special rules, truly significant and meaningful to the participant—but part of the world of play, of make-believe, not to be confused with the larger world of reality.

Except with children, this play-world can never be as real or as important as the larger world outside the arena. When it is so regarded, the image is distorted.

The article mentions the element of truce. As far as we know, the truce of Ophites and Lycurgus was honoured by athlete and spectator alike and the only criterion was athletic ability. But in recent years we have seen, in some international competition, something very near the substitution of one kind of conflict for another. When this happens, sport divides people instead of uniting them. In expounding the ideal we should not close our eyes to the reality.

In Malaya, where there is difficulty in uniting four peoples—English, Chinese, Malays and Tamils—into one nation, sport is being used as a universal medium of education. In the schools this is showing great promise. Children learn quickly to appreciate good performance and conduct, regardless of race and language. It will be interesting to see if sport exercises the same influence at adult level, where ideals are not so important when emotions



run hot. Even so, the simple fact that sport is being used deliberately to bring different peoples closer together is further recognition of the validity of de Coubertin's philosophy.

Sport is character education. This part of the talk must have been severely condensed for, without explanation, it appears trite and overworked. In this context, character and sportsmanship are rarely defined. We seem to be on reasonably sure ground when we discuss the play of children for it is play that does most to develop group and social consciousness in them. This happens because fairness and obedience to rules are not just verbal concepts to children. They become a kind of living, organic morality.

Even so, there is an element of selfishness in this. The group interest gradually becomes the child's interest and a social being is created. Whatever changes may have been effected in the child's attitudes and character during this process, it is still his own interest that is being served. He has, however, adapted it to the group.

When adolescence is reached, attitudes to rules, fairness and appropriate conduct become more particularized and may vary between one sport and another. The codes are not all equally observed. It is here

that we begin to have doubts about sport and character with *some* participants. If the code serves their interests (e.g. winning) then it is obeyed. If it does not serve their interests, it may still be obeyed because of the social pressures of team mates, opponents and spectators, but if it can be broken without censure, this often happens. Is it a virtue to observe a code of behaviour under pressure?

My contention here is that it is too easy and often erroneous to generalize about sport and character, especially among adults. Perhaps its greatest contribution in adult life is self-discovery, the sometimes shattering revelation of one's true status.

This still leaves wide open the whole question of whether sportsmen generalize what they learn on the sports field. Some do. Others don't. And in any case, games are worth playing for their own sake, regardless of moral, public or character values.

It is difficult for some educators to appreciate the importance of sport as culture. Some intellectuals believe that attending a Shakespearean drama is a cultural experience whereas attending a game is beneath the notice of an intelligent person. Is the mime of the sports field any less cultural than the sound of the stage? Is the drama any less intense? Roles in both circumstances have been created externally—the one by an author, the other by an authority. In some ways the stage is much more circumscribed than the field, the action more severely restricted and with less creative opportunity. Many sports events outdo ballet in complexity and beauty of action. Top levels in both require dedication of a high order. Does the mass appeal of one cultural form degrade it?

Movement was a universal language long before the first word was spoken and it speaks even more eloquently in the trained and refined action of the modern athlete. It is hard to understand why seeing the young Hamlet carelessly killing Polonius should be a cultural experience and seeing Valerie Brumel clearing seven feet should not. Motive and plot are deeper and more devious in the former and elemental passions are more acutely involved. Does treason, murder and revenge make Hamlet a cultural drama? Does simplicity of purpose and absence of passion make the drama of the high jump any less cultural? Many believe that skill and perfection of controlled bodily movement are among the most beautiful of human accomplishments.

Culture is not the sovereign right of any group of disciplines. In this context it is surely the complete mastery of some skill, whether this be the perfect manipulation of a musical instrument, the vocal facility of a prima donna, the histrionic ability of the actor, the craft of an accomplished writer or the kinesthetic intelligence of the pole vaulter. And if it is "cultural" to watch the one, it is surely "cultural" to watch the other. Much so-called "cultural" experience comes from watching, provided always that there is real understanding at the same time.

The vexed question of amateurism is a difficult one and many would wish to have ideas as clear cut and definite as these in the UNESCO COURIER article. Undoubtedly, it is time the practical issues of the situation were faced. Practices vary so much from one sport to another. What is condoned in one is condemned in another and this needs tidying up. But we should be aware, as far as possible, of all the implications of paying athletes and games players. Immediately, the sports concept of Plato "for nothing but the sheer pleasure of doing it", is at an end. Payment removes sport from the play element in culture and turns it into work. If players must be paid, so be it, but this will, in turn, alter the whole nature of sport and some other name may have to be found for it.

M. Maheu says that the concepts of Pierre de Coubertin related to a social situation and a stage in the technical development of sport which are now out of date and that the new conditions must be faced. It might be salutary to remind ourselves that sportsmen are under no compulsion to enter expensive and time-consuming activities, nor to provide large-scale spectacles for public amusement. There are many interesting and worthwhile sports which cost very little in either time or money. Might it not turn out that the Olympic Games itself has become too large, too unwieldy, too expensive and too closely allied with national prestige and that *this* is the major factor to be faced, not a fundamental alteration in the rules of amateur sport. Can it be that the Games are not worth the toil, sweat, trouble and expense and that much more good could be accomplished by small exchanges of sportsmen between different countries?

No student of history can fail to have some misgivings at the suggested introduction of professionalism into the Olympic arena. It seems inevitable if the Games are to continue, but it will certainly spell the end of sport as we have known it for the past fifty years.

D. R. Wills
Superintendant of Physical Education for New Zealand, Wellington. N. Z.

THE NEW NATIONS

Sir,

May I compliment you on the excellent presentation and contents of THE UNESCO COURIER. However, I should like to support one of your Soviet correspondents, Anatoly Chetverikov, in asking you to publish articles on the nations which have come into being in recent years and particularly those in Africa. The daily press tells us very little about them, and I for one would like to know more about their ways of life, their resources, their state of civilization and what UNESCO is doing to help their development.

E. Philippe
Bourges, France

GUIDE FOR READERS

Sir,

A collection of issues of THE UNESCO COURIER is a veritable encyclopaedia which presents to its readers a panorama of the work, the resources and the problems of the world, particularly in the context of modern times. But this fine source of documentary material and cultural knowledge should be made into a still more handy tool. One should be able to trace immediately any article it publishes or any subject it deals with without having to thumb through a pile of back numbers. A list published annually of the contents of each issue would solve this problem and would also provide a classification of contents by subject. With this innovation THE UNESCO COURIER would add to its reputation and far greater and more fruitful use would be made of the rich store of facts which it offers readers.

René Barb
Montpellier, France

Ed. note : The possibility of publishing an index for THE UNESCO COURIER *covering the years* 1957-1963 *is at present being studied. Readers will be informed as soon as this project has been completed. We would remind our correspondent that an index of contents published in* 1963 *appeared in our December* 1963 *issue.*

MARTIN-LUTHER UNIVERSITY

Sir,

The credit for the photograph with the article "A Family of Asian Scripts" (March 1964 issue, page 18) of a plaque found in the Indus Valley reads "Archaeological Seminary of the University of Halle, Federal Republic of Germany." The city of Halle, however, is in Eastern Germany, not the Federal Republic of Germany. The university's full name is "Martin-Luther-Universitat, Halle-Wittenberg, in Halle (Saale)."

Werner Hückel
Leipzig, S 3, Eastern Germany

WORLD SOIL SURVEY

Sir,

In THE UNESCO COURIER, (April 1964) there are extremely interesting articles on bacilli and the successful fight against the many ills man is heir to. Consequently world populace grows apace. What about food?

Astronomical sums of money are spent on defence by East and West. What is done to halt the ever diminishing area (by erosion) of cultivatable soil on which human life depends? This problem needs greater attention than ever before.

Could a world survey on this very urgent problem be a subject for a future number? Shortage of food increases tuberculosis and halts the progress of man in many peaceful directions.

T. Kloppenburg
Republic of South Africa

Ed. Note: See our special July/August 1962 *issue on Freedom from Hunger.*

From the Unesco Newsroom...

BOOKS FOR ALL: The world's book production is today concentrated in ten countries and 70% of all translations are made from only four languages—English, Russian, French and German—declared M. René Maheu, Director-General of UNESCO, addressing the Second International Congress of Booksellers, which met in UNESCO House, in June. M. Maheu added that the technical revolution which had made possible low-cost book production on a mass scale must now be extended to developing countries.

KALINGA PRIZE FOR INDIAN WRITER: Jagjit Singh, science writer and adviser on operational research to the Indian Government, has been selected as the 12th winner of the international Kalinga Prize for the popularization of science. Awarded by an international jury appointed by UNESCO, the Kalinga Prize is a personal donation of Bijoyanand Patnaik, an Indian industrialist who is a director of the Kalinga Foundation in India. Jagjit Singh was awarded the prize for his scientific writings, and in particular for those dealing with fundamental theories of cosmology, relativity and space time and astrophysics.

Unesco - C. Bablin

KIERKEGAARD CENTENARY

Young people crowd the aisles in the packed conference hall at Unesco House, Paris, during the international colloquy marking the close of the Kierkegaard Centenary celebrations in April. The debt which modern philosophy owes to the great Danish thinker was underlined by Mr. René Maheu, Director-General of Unesco in his opening address and by internationally-known philosophers such as Jean Paul Sartre, Jean Wahl, Enzo Pace and Gabriel Marcel who spoke at these meetings. The work of Kierkegaard, the centenary of whose birth was celebrated during 1963, and its impact on contemporary thinking were also evoked during a series of round table discussions.

PUPPETERS' RENDEZ-VOUS: Twenty amateur puppet theatre companies from different countries met in Karlovy Vary Spa, Czechoslovakia, recently for an International Puppet Festival. Groups from Great Britain, Australia, Bulgaria, France, Yugoslavia, Hungary, the Federal Republic of Germany, the Soviet Union and Czechoslovakia, among others, gave performances and took part in discussions on the art of the puppeteer during a four-day festival conference.

PROBING THE BLACK CURRENT': A new venture in co-operative research at sea has been launched by the Intergovernmental Oceanographic Commission. Meeting at UNESCO House in June the Commission approved plans for the study of the Kuroshio Current (its name is Japanese and means "black current") in the northwest Pacific. Vessels from six or seven nations will investigate this current, whose variations are believed to influence fishing conditions and the weather in this part of the Pacific.

SMOOTHING TV'S ROAD: Efforts to pave the way for systematic development of television services in Africa will be reviewed at a UNESCO meeting in Lagos, Nigeria, in September. Directors of national TV and broadcasting organizations and other specialists will examine the problems of organization, technology and finance which are posed by the launching of TV in Africa and will discuss how TV can contribute to social, educational and cultural development.

UNESCO'S MONUMENTS CAMPAIGN: One June 2, UNESCO launched a six-months' international campaign for the preservation of historical monuments. Hailing UNESCO's campaign as "an outstanding contribution to the preservation of the world's cultural legacy," President Johnson of the U.S.A. pledged his country's wholehearted support for it.

A TEACHER'S CHARTER: Since 1963 UNESCO and the International Labour Organization have made a joint study of the status of teachers, a problem that affects all educational planning. A further step towards the elaboration of a charter for teachers was taken recently when an international committee of specialists, meeting at UNESCO House, drew up recommendations concerning its scope and content. These referred to the appointment and working conditions of teachers, their relations with education services and their rights and duties. The draft charter will be submitted to an intergovernmental conference in 1966.

UNESCO PLANS FOR 1965-66: UNESCO's proposed programme for 1965-66 calls for a budget of $47,460,000. This draft programme, presented to the UNESCO Executive Board when it met during May and June by M. René Maheu, UNESCO's Director-General, maintains UNESCO's priority on education but also calls for a substantial increase in scientific activities. The programme and budget will be submitted to UNESCO's General Conference which meets in Paris in October and November.

RACE RELATIONS IN AFRICA: For the first time in UNESCO's history, a specialist in race relations has been sent into the field at the request of a member state—in this case the United Kingdom. The specialist chosen is Mr. Kenneth Kirkwood, since 1955 Rhodes Professor of Race Relations at Oxford University, who will occupy the newly-created chair of race relations at University College, Salisbury, Southern Rhodesia. In this post he will study and do research work into the entire problem of race relationships in Africa.

PROTECTING CULTURAL PROPERTY: Measures to prohibit and prevent illicit export, import and sale of cultural property have been proposed by a committee of specialists from 30 countries which met recently in UNESCO House. The action proposed includes the drawing up of national inventories of cultural property, protection measures, international agreements for the restitution of illegally exported objects, and provisions for a bona fide purchaser of illegally exported property to obtain damages or compensation. These recommendations will be presented to UNESCO's General Conference in October.

Flashes...

■ *On June 8, 1964, Iceland became Unesco's 115th member state.*

■ *The Belgian Government has offered $13,000 to Unesco for a survey into the possibility of setting up an institute for basic research into the life sciences.*

■ *The Government of India has asked Unesco to help establish a Commission to survey and assess India's entire educational system.*

■ *Rodolfo Baron Castro, of El Salvador, was recently elected chairman of the Unesco Executive Board in place of Mr. C. Edward Beeby of New Zealand, who has resigned for health reasons.*

■ *Dr. Linus Pauling of the U.S.A., a double Nobel Prizewinner (chemistry, 1954 and peace, 1962) recently gave a talk on "Science Education and Social Responsibility," at Unesco's H. Q. in Paris.*

■ *Through the intermediary of Unesco, the International Development Association has extended a credit equivalent to $4.6 million to enable Tanganyika to build two secondary schools and extend and equip 53 others.*

■ *Under an agreement between the Moroccan Government and Unesco an administrative training and research centre for African development will be opened in Tangiers at the end of this year.*

■ *During recent oceanographic research in the tropical Atlantic, a U.S. Bureau of Fisheries vessel sent its findings direct to the Oceanographic Data Centre in Washington via a communications satellite in orbit over the Brazilian coast.*

Imp. GEORGES LANG, PARIS. IMPRIMÉ EN FRANCE.

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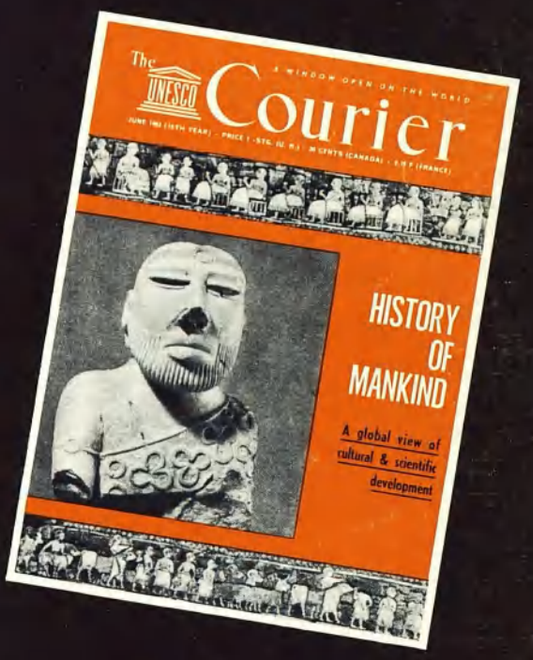

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